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Can Originality Be Taught?

Pitifully few men are engaged in scientific research, in spite of the fact that economic progress is largely attributable to scientific discoveries. Thoughtful men are agreed that we owe very much to scientists who discover, and to engineers who apply the laws of nature. Yet even thoughtful men seldom suggest that there is crying need of vastly more scientific research. We suspect that the reason for this apathy is to be found mainly in a false conception of how scientific discoveries are made.

A great scientist, like Faraday, is commonly regarded as being a genius to whom is given an intuitive power far beyond that of other men. Indeed, great geniuses, like J. J. Thompson, have repeatedly talked of the marvelous intuition of the Faradays; and by this very sort of talk have aided in obscuring the methods by which scientists, great and small, accomplish their results.

If scientific discovery and all other forms of original thinking are the results purely of heriditary gifts, then there is perhaps slight reason in employing men to do original scientific work, for such employment will not add to their native ability, nor will the lack of such employment prevent their genius from flowering. However, it is beginning to dawn on men here and there that Edison was not joking when he said that invention is not the consequence of inspiration so much as of perspiration. And, as a result, research laboratories financed by great corporations are slowly becoming more common. Engineers are being hired to discover the secrets of nature and to make inventions based upon the new knowledge thus acquired.

When you come to consider the matter carefully, every thought is original to some extent. Every pellet of shot differs from every other one, in some degree; and no two ideas are ever more alike than two shot pellets. Even the bird that builds its nest each year like the one of the year before, still builds each nest slightly different from its predecessors. So every bridge that is designed differs from every other one. Bird and engineer alike show some originality in every one of their creations. Originality, then, is the commonest thing in the world. Yet it is usually spoken of as if it were the rarest.

Since originality is not rare, a genius differs from the average man only in degree of mental power and in persistence of its application. Perhaps the degree of difference is not to be measured by the value of their respective achievements. Certainly brain power is not measurable by the wealth that a man accumulates. Why then should we think that it is measurable by any other sort of achievement?

"Full many a mute, inglorious Milton here may lie" appeals to us all as being a poetic line weighted with prosaic truth. Opportunity and training certainly have much to do with any man's success. Then may it not be that geniuses are largely the product of training and of opportunity? We think so.

Methods of attacking engineering problems are successfully taught in our engineering colleges; and these methods presuppose the application of at least some ingenuity. The very word engineer has a common root with genius, and the early use of the word engineer indicated that it was applied only to an ingenious man. Methods of original thinking are taught to engineers even now, but with insufficient accent upon originality.

At least two American universities have turned their teaching largely toward training men to become more original. This indicates a growing belief that originality of a high order is teachable. Once this belief becomes more prevalent we shall see thousands of research engineers where now there is one. Then the secretary of agriculture will no longer have to importune congress to appropriate more than a beggar's pittance for research work. Then our men of great wealth will endow fewer art museums and more research laboratories. Then diseases that now resist the inquiring efforts of a few scientists will capitulate to the massed assaults of hundreds of scientific minds. Then our greatest laudations will not go to some daring soul who has flown to the north pole in a machine invented by another, but to the greater soul who by his science made the machine possible. A far cry it is yet, however, across the oceans of ignorance that lie between the discoverer of a new scientific principle and the discoverer of a speck of ice in which centers the axis of the world.

Bonded Indebtness of 214 Cities

Mr. Rightor's Comparative Debt Statement is an Annual Feature of the National Municipal Review. This Statement Shows the Status of These Communities to January 1, 1927. He Finds the Trend Still Upward

By C. E. RIGHTOR
Chief Accountant, Detroit Bureau of Governmental Research, Inc.

The tabulation presents the total bonded indebtedness of 214 cities as at January 1, 1927, and this total classified as to general public improvements, schools, and utilities; the sinking fund total, similarly classified; the net bonded debt; the net bonded debt excluding self-supporting indebtedness, and the per capita debt for same.

The comparative position of any city may be ascertained easily by inspection. To conserve space, the sinking fund analysis is reported in percentages, rather than in the exact amounts.

It is desired, primarily, to indicate the total amount of bonded indebtedness outstanding as a liability of the assessed property of the city. Ordinarily, the bonds are issued by the city, but in numerous instances it is found that the school board has independent power to issue bonds. Occasionally, they may be issued by a quasi-independent board having authority over a larger metropolitan district. But in any case the property boundaries of the city and the school or other board are co-terminous or nearly so.

The extent of indebtedness for revenue-producing utilities makes it desirable to indicate the relief to the general tax rolls for debt charges which is being afforded through revenues in other forms. This is shown in the difference between the two columns "total net debt" and "net debt excluding self-supporting." The per capita debt reported, accordingly, is for only such portion of the total debt as must be retired ultimately by direct property taxes. Even here difficulties arise, and several cities having self-supporting utilities reported that the utility bonds are to be retired from general taxation.

Special Assessment Debt Omitted.—As has been the custom heretofore, the table omits special assessment debt except the city's portion, and current loans. It is assumed that special assessments are to be made not as *ad valorem* tax levies, but upon assessments against the benefited property only. A comparative table cannot give consideration to debt exemptions established by state and local legislation, as the results of the varying practices among states would impair the value of the figures for comparative purposes.

The results of the compilation are set forth for such limited use as may be made of the figures. Of necessity the tabulation must be in condensed form, so that definite conclusions may safely be drawn only when the detailed data in each case are studied. With only a single purpose in mind in compiling the data, numerous conditions make the problem a complicated one. Varying areas of political subdivisions

City	Census July 1, 1926	General improvement bonds	Public school bonds	Public utility bonds	Total gross bonded debt	Sinking fund: Total	Sinking fund: General improvement (per cent)	Sinking fund: Public school (per cent)	Sinking fund: Public utility (per cent)	Total net bonded debt	Net debt, excluding self-supporting	Per capita net debt excluding self-supporting
Group I												
Population 500,000 and over												
1. New York, N. Y.[1]	5,924,000	$523,357,916	$278,424,000	$797,679,073	$1,599,461,022	$294,405,390	..	..	..	$1,305,055,632	$970,000,000	$163.74
2. Chicago, Ill.[2]	3,048,000	170,975,300	..	6,955,500	183,930,800	..	..	..	..	182,930,800	183,930,800	60.34
3. Philadelphia, Pa.[3]	2,008,000	295,740,100	50,381,000	..	346,121,100	88,529,662	41	..	..	357,591,438	315,591,438*	157.12
4. Detroit, Mich.[4]	1,780,000	91,350,566	57,305,350	59,253,115	207,908,731	18,916,682	41	35	24	189,092,049	142,668,077	110.59
5. Los Angeles, Calif.[5]	1,222,500	50,457,500	62,896,392	100,041,650	213,395,542	12,477,717	9	37	54	199,717,825	107,002,508*	87.52
6. Cleveland, Ohio[6]	960,000	88,743,590	28,970,000	35,959,827	153,673,418	25,499,530	80	12	8	128,173,788	94,415,950	98.35
7. St. Louis, Mo.	820,000	22,935,000	2,230,000	8,427,000	63,601,000	10,393,894	77	6	17	53,207,106	26,538,546	31.97
8. Baltimore, Md.[7]	809,000	110,110,643	14,459,000	27,052,000	151,621,643	36,045,881	93	..	7	115,575,762	91,227,743	112.91
9. Boston, Mass.[8]	787,000	78,188,051	14,129,300	47,973,700	140,291,051	45,211,065	63	17	20	95,079,986	55,975,746	71.00
10. Pittsburgh, Pa.	637,000	28,368,000	18,865,806	8,906,800	56,140,600	3,167,832	38	52	10	51,972,768	54,372,539	85.35
11. San Francisco, Calif.[9]	567,000	20,984,900	16,475,000	46,893,000	84,332,900	2,639,600	40	14	46	81,693,300	54,693,300	120.27
12. Buffalo, N. Y.[10]	544,000	37,580,760	25,262,191	16,616,458	79,439,418	5,718,678	44	..	56	73,720,763	60,334,824	110.91
13. Washington, D. C.	526,000	No Bonded Debt.										
14. Milwaukee, Wis.	517,000	31,252,100	8,097,750	105,000	39,454,850	2,787,750	79	20	1	36,667,100	36,577,100	70.74
Group II												
Population 300,000 to 500,000												
15. Newark, N. J.	459,000	$35,576,000	$15,378,200	$16,444,000	$67,396,200	$12,613,758	58	23	19	$54,782,444	$10,677,491	$23.27
16. Minneapolis, Minn.[11]	434,000	24,606,588	20,578,210	4,052,000	49,356,798	5,738,311	..	..	..	43,618,487	43,618,487	100.50
17. New Orleans, La.[12]	419,000	38,544,500	2,298,000	..	40,842,500	..	..	..	..	40,842,500	40,842,500	97.47
18. Seattle, Wash.[13]	411,578	17,637,500	9,312,000	36,527,500	63,477,000	1,960,625	49	15	36	61,916,375	25,705,489	62.05
19. Cincinnati, Ohio[14]	411,000	54,980,584	13,270,000	42,895,230	111,151,914	32,744,949	61	7	32	78,406,965	52,016,114	126.54
20. Kansas City, Mo.	375,000	16,913,400	19,371,500	13,120,000	49,401,900	9,336,600	28	58	14	40,065,300	28,270,000	61.62
21. Indianapolis, Ind.[15]	367,000	14,168,160	10,757,660	..	24,925,820	1,695,243	59	41	..	23,266,577	23,266,577	63.39
22. Rochester, N. Y.	321,000	17,735,800	9,992,910	11,485,500	39,214,200	5,284,645	32	13	55	33,929,555	25,327,707	78.90
23. Jersey City, N. J.	319,000	18,993,833	12,786,000	18,716,255	50,496,088	9,888,018	64	16	21	40,608,070	41,194,538	81.59
24. Louisville, Ky.[16]	311,000	13,358,500	5,666,400	1,079,000	21,903,900	3,388,539	62	7	11	18,515,241	17,803,374	57.25
Group III												
Population 100,000 to 300,000												
25. Toledo, Ohio	295,000	$23,377,245	$11,946,000	$1,677,000	$37,195,245	$6,586,576	87	12	..	$30,608,669	$29,779,669	$97.39
26. Columbus, Ohio[17]	285,000	18,375,516	10,602,750	9,490,000	38,468,266	12,975,672	87	25	18	25,492,594	19,496,333	68.41
27. Denver, Colo.	285,000	760,000	10,278,500	21,573,600	32,612,100	337,936	87	..	13	32,274,164	10,746,445	37.71
28. Portland, Ore.[18]	282,383	23,110,776	6,739,920	15,578,000	45,428,696	4,607,526	47	..	53	40,821,170	27,757,664	98.30
29. Providence, R. I.	275,900	14,760,000	6,200,000	18,078,000	39,038,000	13,590,041	48	17	35	25,447,959	12,107,701	43.88
30. Oakland, Calif.[19]	261,000	2,263,641	13,191,554	9,874,717	26,329,912	..	..	..	..	26,329,912	18,455,195	62.05
31. St. Paul, Minn.	246,000	13,484,000	9,346,000	7,541,000	30,571,000	3,086,060	65	25	10	27,484,940	21,007,570	94.71
32. Atlanta, Ga.	224,300	4,596,000	3,793,000	2,800,000	11,231,000	2,101,134	39	10	51	9,129,866	8,937,437	30.83
33. Omaha, Nebr.[20]	216,000	13,773,317	10,830,750	11,392,000	35,996,067	4,338,987	17	19	64	31,657,080	22,086,731	108.80
34. Birmingham, Ala.	211,000	7,470,500	7,297,000	190,000	15,057,500	782,366	100	..	..	14,275,132	14,275,132	67.65
35. Akron, Ohio	208,435	20,300,919	7,456,746	10,345,000	38,100,665	2,940,843	83	13	35	35,759,822	36,238,063	125.82
Group III—Continued												
Population 100,000 to 300,000												
36. San Antonio, Texas	205,000	$14,993,500	$3,493,250	$6,949,000	$25,435,750	$1,135,560	49	29	22	$24,300,190	$17,001,105	$82.96
37. Worcester, Mass.	195,000	6,172,000	1,173,500	5,340,000	12,685,500	4,263,107	47	5	48	8,422,483	5,117,663	26.52
38. Richmond, Va.[21]	189,000	22,349,185	4,385,395	6,748,550	33,483,130	8,049,837	..	..	..	25,433,293	18,984,743*	100.44
39. Syracuse, N. Y.	185,000	9,041,231	8,309,022	4,421,375	21,770,628	6,279,874	48	42	10	20,490,754	18,205,004	87.39
40. New Haven, Conn.	182,000	10,933,000	621,000	..	11,556,000	949,186	..	..	..	10,606,814	10,606,814	58.27
41. Dayton, Ohio	177,000	9,709,348	6,324,000	3,942,000	19,975,348	3,153,173	100	..	..	16,822,175	16,822,175	95.07
42. Norfolk, Va.[22]	174,000	17,509,134	4,796,000	15,513,786	37,809,500	4,976,371	98	..	14	32,982,129	18,152,963	104.32
43. Grand Rapids, Mich.	165,000	7,880,938	4,013,500	1,450,000	13,044,438	2,902,879	73	27	..	10,241,559	9,091,559	55.10
44. Hartford, Conn.	164,000	4,653,481	9,735,500	4,915,000	19,303,981	2,836,624	57	24	19	16,467,357	12,098,936	73.71
45. Fort Worth, Texas	159,000	9,423,000	4,400,500	1,609,000	15,432,500	1,974,095	53	5	32	16,458,414	12,468,100	78.54
46. Oakland, Calif.[19]	156,000	4,771,000	5,612,000	3,548,000	13,931,000	1,095,217	44	..	56	12,835,783	9,896,040	63.43
47. Bridgeport, Conn.	155,000	9,154,000	4,298,000	..	13,452,000	..	..	..	..	13,452,000	13,452,000	86.79
48. Des Moines, Iowa	148,000	8,664,779	6,265,500	5,000,000	19,930,279	350,784	17	..	83	19,579,495	13,869,182	94.99
49. Springfield, Mass.	145,000	9,161,500	3,297,900	1,915,000	14,374,400	142,000	..	..	100	14,232,400	12,457,600	85.91
50. Paterson, N. J.	143,000	6,198,186	6,959,500	3,526,896	16,684,582	2,340,517	64	36	..	14,344,247	10,817,451	75.65
51. Nashville, Tenn.[23]	137,000	8,120,000	1,183,000	2,014,000	11,317,000	600,447	..	..	..	11,716,553	11,765,553	85.74
52. Jacksonville, Fla.[24]	137,000	6,873,000	4,698,000	1,750,000	13,321,000	1,674,683	85	15	..	11,646,317	9,936,317	72.22
53. Flint, Mich.	136,000	6,039,000	7,144,400	3,198,500	17,081,900	601,382	14	15	71	16,477,518	12,709,204	100.06
54. Oklahoma City, Okla.	135,000	5,414,500	5,166,601	5,667,000	16,247,900	5,245,906	38	30	32	11,002,094	7,038,127	52.13
55. Trenton, N. J.	134,000	8,780,570	5,341,050	1,019,000	15,140,620	2,875,163	55	26	19	12,393,517	11,832,227	88.30
56. Salt Lake City, Utah	133,000	3,198,500	3,816,000	2,717,700	9,732,200	668,757	24	76	..	9,073,443	6,145,743	46.21
57. Tulsa, Okla.	133,000	3,857,361	4,824,000	9,316,000	17,997,361	2,020,992	34	39	27	15,976,369	15,976,369	120.12
58. Camden, N. J.	131,000	7,302,685	3,679,000	1,215,725	12,194,410	2,786,949	77	16	7	9,407,461	4,367,197*	64.66
59. Fall River, Mass.[25]	131,000	11,255,300	..	1,178,000	12,433,300	2,477,777	59	..	41	10,255,523	10,255,523	78.28
60. Lynn, Mass.	124,000	5,876,600	1,350,000	3,850,000	11,076,600	418,800	100	..	..	10,657,800	6,807,800	54.90
61. Cambridge, Mass.	122,000	7,731,150	735,700	984,000	9,452,900	3,162,299	88	..	12	6,269,601	5,670,324	46.48
62. Erie, Pa.	120,000	4,235,000	3,618,000	720,000	8,113,000	559,938	72	..	28	7,553,061	7,553,061	62.94
63. Fall River, Mass.[25]	119,539	9,561,000	2,503,000	1,367,000	13,431,000	845,276	88	..	12	12,585,726	11,375,726	95.16
64. New Bedford, Mass.[25]	119,000	9,774,267	3,204,100	3,011,000	15,989,367	1,643,968	78	..	22	14,345,399	13,695,984	115.09
65. Albany, N. Y.	118,000	8,702,663	2,752,570	2,810,750	19,356,983	..	..	..	..	19,356,983	16,546,233	142.64
66. Yonkers, N. Y.	116,000	3,021,000	5,803,300	932,000	9,556,300	877,536	28	63	9	8,678,764	7,746,764	67.05
67. Reading, Pa.	113,000	3,169,000	4,475,000	3,435,000	11,079,000	59,036	39	61	..	11,019,964	7,584,964	67.12
68. Duluth, Minn.	113,000	6,419,430	7,367,000	1,693,637	15,480,067	2,730,923	94	6	..	12,749,245	11,055,608	100.81
69. Canton, Ohio	110,000	2,016,066	3,218,550	10,028,168	15,262,784	132,342	..	..	..	15,130,442	5,667,544	49.57
70. Springfield, Ohio	110,000	3,186,200	1,977,000	1,632,000	6,595,200	1,782,273	36	54	10	4,812,927	3,659,330	32.68
71. Spokane, Wash.[26]	109,000	983,500	4,418,350	..	5,321,850	529,000	..	..	100	4,792,850	4,792,850	44.79
72. Elizabeth, N. J.	107,000	4,687,000	2,686,000	6,563,995	13,936,995	1,840,964	98	1	1	12,096,031	5,853,619	52.39
73. Tacoma, Wash.[26]	106,000	3,341,660	1,874,000	1,400,500	6,616,160	821,418	48	..	52	5,794,742	5,620,620	49.58
74. Lynn, Mass.	104,000	8,629,500	4,503,000	2,875,000	15,499,500	1,297,493	95	4	1	14,199,007	11,247,912	110.25
75. Somerville, Mass.	100,000	609,000	849,000	..	1,457,000	..	..	..	..	1,457,000	1,457,000	14.57
Group IV												
Population 50,000 to 100,000												
76. Knoxville, Tenn.	98,888	$10,156,940	$1,818,500	$4,427,000	$16,402,440	$710,808	..	..	..	$15,691,632	$11,294,632*	$124.01
77. Long Beach, Calif.[19]	97,780	5,807,694	7,270,221	4,235,000	17,412,915	778,688	27	68	5	16,686,127	12,491,153	112.45
78. Evansville, Ind.	95,100	1,990,300	2,143,400	..	4,133,700	65,744	100	..	..	4,089,956	4,089,956	43.79
79. Savannah, Ga.	94,900	4,191,500	381,000	250,000	4,822,500	267,000	100	..	..	4,555,500	4,305,500*	45.36
80. Allentown, Pa.	94,600	1,339,200	3,571,000	82,200	4,992,400	594,976	20	78	2	4,397,471	4,227,910*	44.74
81. Lawrence, Mass.	93,500	3,394,750	1,824,500	310,000	5,538,250	24,263	..	..	100	5,513,987	5,319,250	56.92
82. Schenectady, N. Y.	93,000	4,750,700	2,805,900	808,500	8,385,100	90,348	85	..	15	8,294,752	7,941,539	85.37
83. Wichita, Kan.	92,500	3,816,543	1,600,500	..	5,417,043	150,000	67	33	..	5,267,043	5,267,043	56.93
84. Syracuse, N. Y.	91,000	2,502,678	4,659,400	4,015,456	11,177,734	2,107,229	50	49	1	9,070,505	3,060,531	33.61
85. Hamtramck, Mich.	87,900	1,125,180	3,037,500	361,000	4,523,680	292,130	73	27	..	4,231,550	3,870,550	44.01
86. Harrisburg, Pa.	84,000	4,054,000	4,198,500	..	8,249,000	369,353	27	73	..	7,879,967	7,870,967	93.04
87. Manchester, N. H.	84,000	3,125,500	2,179,000	142,000	5,446,500	182,222	100	..	..	5,264,278	5,122,278	60.98
88. Peoria, Ill.	82,500	150,000	657,000	..	807,000	..	..	..	..	807,000	807,000	9.79
89. Long Beach, Calif.	81,700	1,000,000	3,358,000	1,050,000	5,408,000	183,065	83	..	17	5,222,935	4,204,040	51.45
90. Rockford, Ill.	78,400	671,900	1,432,500	350,000	2,454,400	286,000	44	37	19	2,168,400	2,168,400	27.91
91. Rockford, Ill.	78,400	671,900	1,432,500	350,000	2,454,400	359,565	73	27	..	2,094,835	2,094,835	26.72
92. St. Joseph, Mo.	78,400	2,961,850	1,143,000	..	4,004,850	249,337	100	..	..	3,755,513	3,475,263	44.32
93. Wilkes-Barre, Pa.	78,300	2,741,000	500,000	..	3,241,000	150,000	94	16	..	2,991,663	2,991,663	38.21
94. Sioux City, Iowa	78,000	1,910,000	2,100,000	100,000	4,110,000	486,170	84	16	..	3,623,830	3,343,830	42.87
95. Highland Park, Mich.	77,000	3,142,600	4,816,000	1,346,626	9,307,226	2,606,262	32	42	26	6,700,964	6,031,455	78.33
96. Little Rock, Ark.	75,900	1,909,000	2,018,000	..	3,926,000	11,044	100	..	..	3,914,956	3,914,956	51.58
97. Saginaw, Mich.[27]	73,300	3,276,500	..	1,702,000	4,978,500	592,787	72	..	28	4,475,713	2,927,406*	39.94
98. Lansing, Mich.[28]	73,200	1,903,660	..	5,156,200	7,059,860	491,431	17	..	83	6,568,229	1,720,461	24.86
99. Binghamton, N. Y.	72,300	3,150,250	3,350,225	95,000	6,595,475	212,927	100	..	..	6,382,548	6,287,548	86.24
100. Chattanooga, Tenn.	72,200	6,491,700	2,248,500	..	8,740,200	225,789	..	..	..	8,514,411	8,514,411	117.93
101. Johnstown, Pa.	72,200	4,666,500	4,286,000	..	8,952,500	1,185,926	47	53	..	7,766,574	7,766,574	106.73
102. Terre Haute, Ind.	71,900	1,630,000	1,650,000	..	3,270,000	185,885	58	42	..	3,084,115	3,084,115	42.87
103. Winston-Salem, N. C.	71,800	4,650,574	2,489,000	2,968,126	10,116,000	181,000	100	..	..	9,935,000	9,854,994	137.17
104. Hoboken, N. J.	71,000	7,291,743	2,687,635	117,000	11,076,378	1,577,851	94	33	3	9,503,526	9,441,268	132.97
105. Chester, Pa.	70,400	2,967,000	1,833,000	..	4,702,000	1,073,731	80	20	..	3,628,269	3,628,269	51.53
106. Springfield, Ohio	70,200	1,651,517	1,612,482	235,000	3,549,000	732,062	86	14	..	2,816,947	2,816,947	40.49
107. Miami, Fla.	69,754	14,743,500	9,296,000	1,870,000	25,857,500	2,190,594	84	12	4	23,661,436	21,337,386	306.00
108. New Britain, Conn.	69,500	1,960,000	3,041,000	1,596,000	6,597,000	670,996	27	18	55	5,926,004	5,001,000	71.95
109. Passaic, N. J.	69,000	4,600,060	1,918,250	1,940,000	8,458,310	910,223	48	52	..	7,548,087	7,548,087	109.39
110. Berkeley, Calif.	67,740	531,502	2,597,750	..	3,129,252	57,651	..	100	..	3,066,602	3,066,602	45.27
111. Altoona, Pa.	67,000	1,196,000	2,135,000	707,000	4,038,000	900,795	78	22	..	3,137,205	2,430,205	36.85
112. Brockton, Mass.	65,343	1,910,350	788,750	1,598,700	4,199,800	584,008	..	..	100	3,615,792	2,899,100	44.36
113. Bethlehem, Pa.	61,600	2,285,000	4,009,000	1,876,000	7,961,000	1,217,314	82	48	..	6,744,686	6,744,586	109.73
114. Union City, N. J.	63,000	3,645,584	1,655,500	..	5,301,084	458,376	..	..	..	4,842,708	4,842,708	76.90
115. Quincy, Mass.	61,000	2,043,500	2,172,500	862,000	5,078,000	..	..	..	..	5,078,000	4,716,200*	65.02
116. Lincoln, Neb.	61,000	486,000	4,487,100	359,500	5,327,000	74,975	9	13	78	5,252,025	4,951,175	79.82
117. Roanoke, Va.	61,000	4,243,000	1,900,000	..	6,143,000	626,074	..	..	..	5,516,926	5,516,926	89.12
118. East Orange, N. J.	61,700	2,639,500	2,199,243	1,499,000	6,337,743	1,336,758	20	27	53	4,980,987	3,952,417	68.12
119. Holyoke, Mass.[29]	60,400	2,393,000	81,000	2,214,000	4,688,000	507,680	55	..	45	4,180,320	2,474,000	40.96
120. Fresno, Calif.	60,200	695,000	4,210,000	..	4,905,000	..	..	..	..	4,905,000	4,905,000	81.45
121. Portsmouth, Va.	59,900	3,178,700	823,000	2,150,000	6,151,700	950,712	30	..	70	5,200,988	5,730,256	95.68
122. Bethlehem, Pa.	59,100	2,318,000	4,683,870	179,500	8,181,370	1,141,961	99	1	..	7,039,409	6,875,950*	115.58
123. Shreveport, La.	59,300	2,045,500	2,221,000	2,425,000	6,701,500	327,789	8	92	..	6,373,711	3,938,711	66.19
124. Macon, Ga.	59,200	1,789,000	500,000	840,000	3,229,000	54,446	100	..	..	3,174,554	1,794,554	29.30
125. Pasadena, Calif.[30]	58,600	4,079,191	5,075,000	2,337,759	12,091,950	273,470	50	..	50	11,818,480	9,816,706	164.67
126. Niagara Falls, N. Y.	58,300	4,937,650	4,488,119	1,815,130	11,240,899	..	..	..	..	11,240,899	9,452,769	161.67
127. Wichita Falls, Texas	58,028	1,770,000	1,770,000	962,000	5,143,000	282,561	20	40	40	5,150,439	4,321,907	74.48
128. Lancaster, Pa.	57,100	985,000	2,000,000	..	2,985,000	251,013	..	100	..	2,733,987	2,733,987	47.88
129. Kalamazoo, Mich.	54,500	129,500	2,499,000	78,000	2,706,500	27,640	..	100	..	2,678,860	2,600,860	48.75
130. Atlantic City, N. J.	53,800	13,777,300	4,307,000	2,980,000	21,074,300	3,375,687	58	13	29	17,698,613	15,962,586	296.11

*Estimated. Population 20,000 to 100,000													
160 Oak Park, Ill.	53,500	$ 369,000	$1,024,000	$ 100,000	$1,553,000	.....	..	..	..	$1,553,000	$1,393,000*	$ 36.08	
161. Kenosha, Wis.	52,700	324,000	2,379,000	345,000	3,048,000	.....	..	..	..	3,048,000	2,893,000*	51.10	
162. Davenport, Iowa	52,460	1,617,300	1,309,000	.....	2,926,300	$122,454	30	70	..	2,692,846	2,692,846	51.32	
163. Malden, Mass.	52,400	1,701,000	841,400	32,000	2,574,400	233,953	91	..	9	2,340,447	2,329,917	44.46	
164. Cedar Rapids, Ia.	57,100	1,154,300	1,511,000	286,000	3,051,300	30,329	..	100	..	3,040,980	2,644,980	50.77	
165. Woonsocket, R. I.	51,100	7,082,000	792,000	1,039,000	8,913,000	1,902,707	63	..	15	7,010,293	6,752,458*	122.35	
170. New Castle, Pa.	50,700	912,000	1,715,000	.....	2,627,000	27,349	88	12	..	2,599,651	2,599,651	51.27	
Group V													
Population 50,000 to 60,000													
171. Pontiac, Mich.	49,800	$1,180,500	$2,216,000	$1,212,500	$4,809,000	$110,454	1	99	..	$4,192,546	$2,980,046*	$59 81	
175. Haverhill, Mass	49,232	1,294,000	497,000	124,000	1,820,000	276,645	30	29	30	1,543,355	1,501,835	30.51	
176. Bay City, Mich.	49,700	500,000	2,060,000	1,946,000	4,506,000	867,988	49	47	3	3,638,012	2,015,930	40.57	
178. Elmira, N. Y.	49,000	1,677,000	624,000	1,140,000	3,436,000	.....	..	..	..	3,436,000	2,296,000*	46.78	
182. Chelsea, Mass.	48,200	2,007,730	1,297,250	.....	3,304,980	555,534	67	33	..	2,749,426	2,749,426	57.04	
183. Perth Amboy, N. J.	48,182	1,158,000	1,849,500	1,741,000	4,747,500	758,116	29	32	39	3,989,384	2,347,957	48.83	
184. Fitchburg, Mass.	48,100	1,072,000	463,000	852,000	2,387,000	.....	..	..	..	2,387,000	1,536,000*	31.93	
185. Lima, Ohio	47,700	4,055,304	1,152,282	1,095,300	6,300,886	401,993	100	..	..	5,898,911	4,803,611	100.74	
186. East Chicago, Ind.	47,300	1,015,365	.....	1,871,000	2,886,365	81,306	22	..	78	2,805,059	997,759*	21.10	
190. New Rochelle, N. Y.	45,800	3,941,341	3,450,676	.....	7,391,917	908,106	100	..	..	6,983,811	5,983,811	152.48	
193. Waco, Texas	44,800	2,056,500	1,349,700	809,000	4,115,200	800,888	45	19	36	3,314,312	3,314,312	73.98	
194. Jamestown, N. Y.	44,300	1,230,518	1,340,000	1,159,500	3,730,018	47,130	100	..	..	3,772,888	2,660,518	60.03	
195. Muskegon, Mich.	44,300	1,398,000	1,570,000	501,000	3,777,000	100,000	70	..	30	3,672,000	3,198,000	72.18	
196. Fitchburg, Mass.	44,200	1,628,100	534,000	397,500	2,559,600	.....	..	..	..	2,559,600	2,162,100*	48.91	
198. Brookline, Mass.	43,900	763,000	905,400	499,300	2,167,700	.....	..	..	..	2,068,300	1,568,300	35.74	
199. Durham, N. C.	43,900	6,527,625	824,109	3,743,666	9,095,400	652,972	100	..	..	8,442,428	8,442,428	192.31	
202. Battle Creek, Mich.	43,300	1,067,500	766,000	.....	1,867,500	.....	..	..	..	1,867,500	1,867,500	42.81	
205. Lorain, Ohio	43,100	1,815,500	1,663,723	684,000	4,163,223	490,401	79	2	19	3,616,824	2,977,158	69.07	
207. Salem, Mass.	42,900	1,229,000	276,500	440,000	2,015,500	.....	..	..	..	2,015,500	1,605,500	37.42	
208. Hamilton, Ohio	42,900	1,391,734	707,922	1,585,550	3,685,316	209,734	..	..	..	3,475,582	2,163,582	50.55	
209. Springfield, Mo.	42,600	44,000	817,500	.....	861,500	56,066	16	84	..	805,434	805,434	18.21	
210. Everett, Mass.	42,500	1,312,800	784,500	83,000	2,181,300	379,912	100	..	..	1,801,388	1,718,388	40.43	
213. Dubuque, Iowa	41,600	1,337,913	1,316,000	265,000	3,918,913	53,943	21	79	..	3,864,970	2,642,013	63.52	
219. Taunton, Mass.	41,200	1,236,300	699,000	1,417,500	3,352,800	378,621	2	4	94	2,696,179	2,696,179	67.63	
220. Superior, Wis.	39,671	843,673	1,322,000	.....	2,165,673	167,824	100	..	..	1,997,851	1,997,851	50.36	
221. West New York, N. J.	39,197	2,801,970	1,791,500	.....	4,593,470	459,987	100	..	..	4,133,483	4,133,483	105.48	
223. New Brunswick, N. J.	38,900	1,826,000	1,491,000	416,000	3,733,000	98,108	100	..	..	3,634,892	3,018,892	77.61	
224. Phoenix, Ariz.	38,680	1,305,500	2,520,000	2,427,000	6,252,500	470,305	23	71	6	5,892,194	3,483,309	90.08	
225. Lynchburg, Va.	38,693	2,472,000	1,080,534	1,753,000	5,311,766	1,331,207	61	..	39	3,977,559	2,724,559	70.76	
226. Austin, Texas	38,200	929,000	1,068,000	1,084,000	3,081,000	87,519	38	62	..	2,973,481	2,973,481	77.83	
228. Wilmington, N. C.	37,700	1,581,822	651,000	1,102,000	3,334,822	145,879	25	75	..	3,188,943	2,086,943	55.35	
230. Ogden, Utah	37,600	1,778,000	968,000*	897,500	3,643,500	.....	..	..	..	3,643,500	3,623,500*	96.37	
231. East Cleveland, Ohio	37,552	2,051,360	2,307,000	70,300	4,427,660	643,381	60	40	..	3,784,279	3,784,279	101.05	
233. Waterloo, Iowa	36,900	837,679	1,458,500	325,000	2,621,179	60,000	100	..	..	2,561,179	2,236,179*	60.60	
234. Hazleton, Pa.	36,860	1,341,500	1,301,500	.....	2,643,000	101,811	30	70	..	2,541,189	2,491,189	72.86	
Group V—Continued													
Population 50,000 to 60,000													
235. Meriden, Conn.	38,600	$ 610,000	$ 940,000	.....	$1,550,000	.....	..	..	..	$1,550,000	$1,550,000	$ 40.15	
236. Petersburg, Va.	38,400	2,959,000	800,000	$ 500,000	4,259,000	$1,155,838	..	..	..	3,103,171	2,603,171	67.78	
237. Colorado Springs, Colo.	36,000	854,000	1,203,000	3,146,000	5,203,000	.....	..	..	..	5,203,000	2,057,000	57.14	
238. Orange, N. J.	35,800	2,080,000	1,642,000	625,000	4,147,000	824,528	48	27	27	3,322,472	1,117,931	87.08	
239. Poughkeepsie, N. Y.	35,800	1,850,247	906,100	916,000	3,674,347	86,514	17	8	..	3,587,833	2,371,833	74.83	
241. Auburn, N. Y.	35,677	641,536	100,000	257,000	998,536	43,367	..	..	100	955,170	741,637	20.78	
242. Amsterdam, N. Y.	35,600	381,000	1,484,230	301,000	2,166,230	170,699	14	7	79	1,995,531	1,829,269	51.38	
243. Lewiston, Me.	35,500	632,000	123,000	439,000	1,297,000	125,000	100	..	..	1,172,000	733,000	20.64	
244. Norristown, Pa.	35,300	306,500	.....	.....	306,500	55,450	100	..	..	251,050	251,050	7.11	
246. Clifton, N. J.	34,742	1,179,600	1,680,400	1,282,000	4,252,000	124,565	40	60	..	4,127,435	2,745,000	79.02	
247. Warren, Ohio	34,679	807,037	2,573,402	1,191,450	4,571,889	356,515	65	35	..	4,206,274	3,074,824	88.68	
248. Moline, Ill.	34,500	21,500	211,000	60,000	292,500	737	100	..	..	291,763	231,763	6.72	
249. Cranston, R. I.	34,471	1,021,000	821,500	.....	1,833,500	336,746	51	49	..	1,496,754	1,496,754	47.42	
253. Cumberland, Md.	33,741	1,143,000	1,875,000*	2,219,900	5,237,900	498,895	38	..	62	4,741,005	2,879,105*	84.94	
254. Revere, Mass.	33,261	935,798	1,016,570	165,225	2,117,593	.....	..	..	..	2,117,593	1,952,368*	58.70	
256. Irvington, N. J.	33,108	1,346,383	2,391,150	.....	3,737,533	316,777	82	18	..	3,420,757	3,420,757	103.34	
257. Watertown, N. Y.	32,100	625,935	725,500	1,253,000	2,804,435	1,026,566	44	37	19	2,664,987	1,438,052	45.45	
258. Montclair, N. J.	32,022	2,443,210	4,828,500	2,370,000	9,741,710	777,801	16	80	4	8,963,909	6,637,513	201.60	
260. Muskogee, Okla.	32,300	1,704,154	1,255,000	884,000	3,843,154	1,634,402	30	32	38	2,018,752	1,815,652*	55.86	
262. Alameda, Calif.	31,676	290,668	616,459	125,743	1,032,850	.....	..	..	..	907,406	907,406	28.47	
264. Plainfield, N. J.	31,748	1,905,000	1,374,500	.....	3,279,500	173,443	63	37	..	3,106,055	3,106,055	97.83	
268. Kearny, N. J.	31,291	1,824,000	1,736,500	702,000	4,262,500	829,500	60	37	3	3,433,000	2,730,880	88.30	
271. Richmond, Ind.	30,495	191,000	727,900	.....	918,900	7,638	100	..	..	911,262	911,262	29.88	
274. Bloomington, Ill.	30,421	220,000	120,000	140,000	480,000	181,096	19	..	81	327,994	308,750	10.15	
275. Clarksburg, W. Va.	30,402	377,300	.....	291,300	668,600	81,981	94	..	6	667,319	340,314	9.98	
279. Rome, N. Y.	30,328	388,167	799,000	618,000	1,774,167	176,702	100	..	..	1,547,464	1,324,464	43.67	
280. Sioux Falls, S. D.	30,127	1,165,000	1,262,000	426,000	2,998,000	763,395	25	55	20	2,242,605	1,958,378	65.00	

City	Census July 1, 1926	General improvement bonds	Public school bonds	Public utility bonds	Total gross bonded debt	Sinking fund				Total net bonded debt	Net debt, excluding self-supporting	Per cent net debt excluding self-supporting
						Total	General improvement (per cent)	Public school (per cent)	Public utility (per cent)			
CANADIAN CITIES												
1. Montreal, Que.*	942,575	$94,760,036	$30,109,530	$31,464,445	$156,433,311	$15,543,554	82	18	..	$140,889,757	$109,425,212	$116 06
2. Toronto, Ont.*	556,691	44,705,955	23,468,047	87,328,979	155,700,981	24,362,460	43	16	41	131,338,512	53,844,713	96 72
3. Winnipeg, Man.*	197,129	9,960,390	9,025,000	26,674,587	45,667,978	12,865,036	34	19	47	33,801,999	12,503,962	63 58
4. Vancouver, B. C.*	129,356	20,993,924	4,906,906	8,199,351	32,300,175	8,691,684	69	13	19	23,608,491	15,762,282	146 16
5. Quebec, Que.*	124,341	13,213,436	2,922,500*	4,916,750	22,016,686	1,458,246	65	35	0	20,558,340	20,558,340*	165 37
6. Hamilton, Ont.*	122,403	10,389,903	4,353,706	6,162,817	20,906,426	5,034,573	50	14	36	15,851,862	11,496,862	93 95
7. Ottawa, Ont.*	118,697	9,533,778	3,970,319	4,943,158	18,447,254	4,392,180	52	19	29	14,055,074	10,398,808	87 61
8. Calgary, Alb.*	69,000	12,158,533	2,843,250	8,423,012	23,424,795	6,724,548	57	..	43	16,500,247	10,964,291	159 19
9. Edmonton, Alb.*	66,378	18,964,254	3,940,217	11,912,596	34,817,067	8,681,063	27	4	69	26,130,973	19,363,711	296 17
10. London, Ont.*	64,374	4,828,394	2,114,704	3,841,229	10,784,327	1,845,358	36	24	40	8,918,969	5,820,114	90 55
12. Windsor, Ont.*	56,433	6,251,108	4,196,436	1,901,743	12,351,285	124,407	40	60	..	12,226,878	8,909,129	157 87
13. St. John, N. B.*	55,000	2,221,228	1,655,500	3,454,102	9,330,830	2,895,942	91	9	..	6,434,888	3,941,918	71 65
14. Regina, Sask.*	40,000	6,563,449	1,534,650	5,078,483	13,276,582	4,397,046	61	10	29	8,879,534	5,054,565	126 36
15. So. Vancouver, B. C.	40,000	5,389,942	1,056,644	1,013,050	7,459,636	960,534	71	14	15	6,499,107	6,403,357	160 08
16. Victoria, B. C.	40,000	10,278,232	1,354,949	4,081,732	15,712,913	2,363,980	45	27	28	13,349,039	9,537,012	240 28
19. Saskatoon, Sask.*	30,000	4,090,943	1,888,423	2,332,239	9,309,605	2,698,515	56	7	37	6,610,090	4,273,273	142 44

Notes. The cities are arranged in order of population, according to the 1926 (July 1) estimates by the Bureau of Census, with exceptions noted by that Bureau. Population of Canadian cities is as estimated at January 1, 1926. Missing numbers are of cities not furnishing data.

*Estimated.

1 New York City. Debt includes corporate stock note,—short term notes issued in adance of bonds; general bonds include $12,319,083 for libraries; utility bonds, in addition to water, include rapid transit, $354,512,985, and docks and ferries $158,462,760; sinking funds are not separated because there are seven sinking funds, some for several purposes, and analyzed with difficulty.

2 Chicago. Does not include county or forest preserve district (county) bonds, $25,492,000. Ninety-one per cent of the taxable values of the county are within the city of Chicago.

3 Philadelphia. Includes city and county of Philadelphia; general and utility debt not separated.

4 Detroit. Utility bonds include street railway, $23,258,000, and lighting, $8,727,000; in addition to the bonded debt there is a street railway purchase contract for $12,580,000.

5 Los Angeles. Census is local estimate; general bonds include flood control (county), $13,-310,000; utility bonds include light and power, $35,125,000, and harbor, $20,969,000; school bonds are issued by the county; school sinking fund includes flood control.

6 Cleveland. Utility bonds include light and power, $7,770,000.

7 Baltimore. General bonds and sinking fund include school, dock, harbor and conduit.

8 Boston. Utility bonds include rapid transit, $46,729,700; gross debt does not include county, $1,531,500, with sinking fund $538,182, which is paid by Boston.

9 San Francisco. General bonds include 1915 Exposition, $2,600,000; utility bonds include street railway, $3,493,000.

10 Buffalo. Data as at May 1, 1927.

11 Minneapolis. General bonds include net special assessment bonds, $3,194,098; utility bonds include light and power, $50,000, and market, $25,000; sinking funds not separated by purposes.

12 New Orleans. No sinking fund, bond maturities being pre-arranged for retirement in series from tax levies; debt reported does not include Orleans levee district, co-extensive with the city of New Orleans.

13 Seattle. Utility bonds include light and power, $20,185,000, and street railway, $12,742,-500.

14 Cincinnati. Utility bonds include rapid transit, $6,100,000, and Cincinnati Southern Railway, $21,832,000; rental revenues of the city from the latter yield $474,531 to pay interest on $10,545,000 general debt.

15 Indianapolis. General bonds include park district, $3,049,000, and sanitary district, $3,-696,000.

16 Louisville. The sinking fund owns also the entire capital stock of the Louisville Water Company, worth at least $25,000,000.

17 Columbus. Utility bonds include light and power, $1,890,000.

18 Portland. General bonds include docks, and city's portion (94.4 per cent) of port, $3,897,-776; school bonds are 97.68 per cent of the total, based on the city's portion of school district assessed valuation; utility bonds include golf, $90,000; city's share (92.41 per cent) of county debt, $6,058,205, largely for city highways and bridges, is not included.

19 Oakland. Utility bonds include city's portion (65 per cent) of water district, and harbor, $3,374,717.

20 Omaha. Utility bonds include gas, $4,500,-000.

21 Richmond. Utility bonds include light and power, $300,000, and gas, $3,342,550.

22 Norfolk. Utility bonds include dock and terminal, $6,423,948.

23 Nashville. Utility bonds include light and power, $333,000.

24 Jacksonville. Utility bonds include light and power, $650,000.

25 Fall River, Saginaw, East Chicago, Norristown, Clarksburg, Quebec. School debt not reported.

26 Wilmington. Utility bonds include harbor, $2,300,000; school bonds include $235,000 which are a liability of the state.

27 New Bedford. Utility bonds include cemeteries and wharf, $57,000.

28 Spokane. Utility bonds include crematory plant, $70,000.

29 Tacoma. Utility bonds include light and power, $4,135,000, and street railway, $348,000.

30 Long Beach. Utility bonds include gas, $3,-000,000.

31 Lansing. Utility bonds include light and power, $3,826,200, of which $751,200 are first mortgage bonds assumed when the city purchased the utility.

32 Holyoke. Utility bonds include gas and electric, $1,188,000, and Holyoke and Western Railroad, $183,000; sinking fund includes railroad stock at par, $226,500.

33 Pasadena. Utility bonds include light and power, $944,550.

34 Montreal. School debt includes Roman Catholic and Protestant school boards; general sinking fund includes school boards, administered by city treasurer; debt of metropolitan commission, to which city contributes, not included.

35 Toronto. Utility bonds include light and power, $23,304,471, and street railway, $40,748,-567.

36 Winnipeg. Utility bonds include light and power, $16,427,000, steam heating, $1,000,000, and housing, $2,650,000.

37 Vancouver. The Greater Vancouver water district pays debt service on $3,728,970 of the water bonds reported.

38 Hamilton. Utility bonds include light and power, $2,525,975.

39 Ottawa. Utility bonds include light, $963,-215.

40 Calgary. Utility bonds include light and power, $2,619,630, and street railway, $2,545,174.

41 Edmonton. Utility bonds include light and power, $3,569,283, street railway, $3,055,080, and telephone, $2,319,075.

42 London. Data are as at January 1, 1926. Utility bonds include light and power, $1,355,-409, and electric railway, $1,246,329.

43 Windsor. General bonds include housing, $1,416,006; utility bonds include light and power, $1,011,687.

44 St. John. Utility bonds include light and power, $660,846, harbor and wharves, $1,467,165, and markets, $70,000.

45 Regina. Utility bonds include light and power, $1,833,719, and street railway, $170,918.

46 Saskatoon. Utility bonds include light and power, $1,830,947, and street railway, $894,036.

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incurring debt, difficulties of classification, etc., are common problems. For example, the school district frequently is not co-terminous with the city, and more occasionally is an independent political unit. Park, sanitary, port, flood prevention, and other metropolitan districts may exceed the city limits, and the question arises what portion of the debt shall be reported. Difficulties of classification arise in determining whether library is a general or a school debt, whether markets are a general improvement or a utility, etc. In each case, attempt is made to follow the procedure which will be most nearly uniform for comparative purposes.

How shall the sinking fund be classified? In some cases it will be noted the table reports a sinking fund but with no distribution by purposes, as no basis was reported. Also several cities report no sinking fund, which condition, rather than indicating an inadequate financial procedure, may be evidence merely that such city has only serial bonds outstanding.

To a constantly increasing extent, municipalities are issuing serial bonds and restricting maturities to conform with the reasonable period of usefulness of the improvement. The Bond Buyer estimates that the average life of all serials is possibly only seven or eight years, rather than the ten to fifteen years formerly estimated.

Range in Net Debt.—Analysis of the figures of net non-self-supporting debt shows that the city having the lowest

debt, excluding Washington which has no debt, is Moline, with a per capita debt of $6.72. The higest per capita city is Miami, $314.50, but it is probable that the estimate of its population is too low and does it an injustice. For the Canadian cities the range is between the same cities as in 1926—from Winnipeg with a per capita of $63.88, to Edmonton, $296.17; both cities showing a slight increase during the year.

It is interesting to observe that the average net per capita debt of cities by the five census groups, for those cities reporting in this tabulation, increases with population. The average per capita debt for the sixty-two reporting cities in Group V is $62.92; and increases gradually by groups to $111.86 for the thirteen cities in Group I (omitting Washington). In this connection, the census bureau's Financial Statistics of Cities for 1925, which includes 247 cities over 30,000, reports a net per capita debt of $114.33, but this figure includes self-supporting debt which is omitted in the per capita figures of this table. For sixteen Canadian cities, the net debt excluding self-supporting is $117.40 per capita.

The Trend of Municipal Debt.—The census bureau reports also, for 146 cities for which data have been compiled by it since 1903, that the average net bonded debt has increased from $50.94 per capita in 1905 to $119.45 in 1925, or an increase of 134 per cent in twenty years.

An analysis of the data submitted by thirteen of the largest cities, excluding New York City and Washington, for the past five years disclosed that the aggregate net debt had increased from $950,700.000 on January 1, 1923, to $1,269,900,000 on January 1, 1927, or 33.5 per cent. By purposes, this net increase is distributed $181,300,000, or 57 per cent, for general public improvements; $61,200,000, or 19 per cent, for schools; and $75,700,000, or 24 per cent, for utilities.

The Bond Buyer reports sales of state and municipal bonds during 1926 amounting to $1,360,000,000. It is safe to assume that maturities are not occurring at this rate, and hence the net debt of our municipalities is definitely upward. A note of caution, however, might be added that the aggregate compilation of sales is not a true index of the net increase in debt, as maturities and sinking fund accretions serve as a reducing offset, probably reducing the net annual increase to approximately two-thirds of a billion dollars. This condition is a natural one, for if the population of our cities grows apace, there are new needs—and opportunities—for such physical facilities as highways, sewers, water supply, schools and other public buildings, parks, etc. Their cost cannot reasonably be met, especially so soon after the World War, from taxes and current revenues. It seems unreasonable to compare the trend of local debt with that of Federal debt unless the conditions affecting both are taken into account.

Certain it is that the taxpayers look with favor upon the action of their local officials in providing the means for added public welfare, when they continue to approve bond issues so liberally. Again quoting the Bond Buyer, a tabulation made by it discloses that during the first three months of 1927 the voters in 149 municipalities in 30 states approved bond issues totaling $50,800,000. For example, Chicago recently voted $21,390,000 for 13 separate proposals, by a five to one vote. Every election tells a similar story.

Assessed Valuation.—It is of interest to know the relation of the total gross or net debt to the assessed valuation of any city. Such information may be obtained by reference to the assessed valuations reported by the cities in the comparative tax rate data published in the December, 1926, National Municipal Review.

Banking Legislation.—The continued growth in municipal debt and the necessity for many cities to sell their bonds in the New York market, leads to an interest in knowing the future of the banking legislation in that state. The 1927 legislature gave consideration to several bills which proposed a decided liberalization of securities which would be legal investments for savings banks and trusts in that state. These bills seemed to be too radical, however, and the Campbell bill was finally enacted. This bill changed the default provisions of the law, and also legalized the bonds issued prior to May 1, 1929, by any city, outside New York state, the stock or bonds of which have been authorized investments for savings banks at any time since January 1, 1925, provided the city had a population in the 1920 census of not less than 100,000 and has the power to levy taxes for their payment without any limitation as to rate or amount. The first provision benefits a few cities, as Fort Worth, St. Joseph and Memphis; and the second provision places Philadelphia and Richmond upon the legal list. The bill appears to be interim legislation, pending the study before the next legislature of exactly what the present day requirements of the bond market are, possibly along the lines of the Mastick-Fisher bill, which proposed a permanent legal status for the no-tax-limit bonds of large cities upon either a population or property valuation basis.

The Model Bond Law.—Widespread interest has been manifested in the model bond law, promulgated by the National Municipal League, and subsequent legislation affecting municipal indebtedness may be expected in several states to be based at least in part upon the sound financial features advocated in that law. The essential features of that law merit careful study. Although the tendency is definitely toward serial bonds, a minority of the committee which drafted the law suggested that large cities be permitted to issue sinking fund bonds.

Blanks were sent to 280 cities in the United States and 19 cities in Canada. It is a matter of regret that many cities failed to reply to these inquiries, but the cordial cooperation of the larger number leads to the belief that other cities may reply in the future.

St. Louis County Sewer Law Held Invalid

Measure of 1921 Declared Void Because of a Restricted Application

The recent decision of the Supreme Court at Jefferson City, Mo., holding unconstitutional the St. Louis County sewer law of 1921 has no bearing whatever upon the Ralph sewer law passed by the Missouri General Assembly at the 1927 session.

The 1927 statute which is assailed in a suit now pending in the Supreme Court, was a revision of the law of 1925, which was held invalid by the Supreme Court because its title made it applicable only to St. Louis County.

The law held invalid recently gave the County Court power to establish sewer districts, appoint commissioners and fix the compensation of commissioners and employes.

It provided for the payment of sewer construction through special tax bills.

The law of 1921, held invalid yesterday, and of 1925, which was annulled by the Supreme Court in July, 1926, were declared unconstitutional because their titles restricted their application only to St. Louis County.

The titles of each made them applicable only to counties having 100,000 and less than 200,000 adjacent to a city which now contains or may hereafter contain a population of 500,000 or more. Only St. Louis County is so situated.

Judge McElhinny, who issued an injunction against the starting of sewer construction in a district formed under the 1921 act, was sustained by the Supreme Court.

The Ralph law of 1927 puts the administration in the hands of the Circuit Court, and Judge McElhinney created the first St. Louis County sewer district May 16 by appointing three supervisors for a district comprising all of Webster Groves, a strip of territory about it, and a part of Shrewsbury. It is the formation of this district which opponents are fighting in Supreme Court, holding the Circuit Court is without such administrative rights as are conferred by the Ralph law, that its title is defective and that taxpayers were not given sufficient notice.

Paving Methods on an Illinois Super-Highway

How State Paved Road in Cooperation with Villages and Federal Government After Removal of Old Pavement—The Batching Plant—Subgrading—Design of Slab—Paving Operation —Finishing—Curing—Inspection—The Forces Used

Over three miles of concrete pavement, laid to the section shown in Fig. 1, have just been completed on Roosevelt Road, in Cook County, Ill. This work was done under the direction of the Illinois State Highway Commission for the State of Illinois, plus a further section of about a mile owned in part by the United States and in part by the village of Maywood. The original contract called for 75,000 sq. yd. of concrete pavement at $1.76, plus 18,000 cu. yd. of grading at $0.85, and 6,000 cu. yd. Class C excavation at $1.50. The work done on government property and upon the property of the village of Maywood comprised a separate contract at similar prices. On the state contract, the price quoted for pavement included all but the cement, which was furnished by the state.

The Section.—As shown in Fig. 1, the pavement has a total width of 40 ft., to which a 4-ft. shoulder is to be built up on each side. It consists of two 20-ft. thickened edge sections separated by a metal joint along the center line, and each further divided by a metal joint at their midsections and tied together at these latter joints by means of ½-in. diameter deformed bars 4 ft. in length spaced 5 ft. centers across these joints. A ⅞-in. diameter round shear bar, painted and oiled, held in place by bar rests, reinforces each thickened edge at sides and center. The design calls for a 4-in. crown, 9-in. thickness at the edges and center, and a 7-in. thickness of the balance of the slab. The edges are thickened to 9 in. for 12 in. of width at each edge, as shown in the drawing, and then taper to the 7-in. thickness in a distance of 24 in.

Batching Plant.—Since the job was based on an average progress of about 600 lin. ft. of 20-ft. slab per 9 hour working day, since the paver would handle 6-bag batches of the specified 1:2:3½ concrete (with correction addition of 15 per cent sand and 6 per cent gravel) at this rate with a mixing time of 1 minute, with another 30 seconds for charging and discharging with the drum in motion, and since the pay haul distance to the paver average ¾ mile, the following plant was found best adapted to the needs of the job, capable of turning out 300 to 325 batches per day.

The July issue of Roads and Streets contained the story of how worn out Roosevelt Road, in Cook County, Ill., was stripped of its wartime 18-ft. pavement in order to make way for a modern superhighway to be constructed by the Illinois State Highway Commission. At that time the actual work of paving had not yet been started. A return visit to the job during the past month revealed that the paving of the present contract had progressed nearly to completion, and but a fraction of a mile yet had to be done. This present story, then, is a fitting sequel to the former article, and shows how the contractor laid the new slab. It represents, in its equipment and its organization, the final results of the experiences on the job, with the natural correction of plant, equipment and organization that comes from such experience. It may be noted here that the work in every way appears typical of modern methods used on concrete paving work somewhat isolated from the large city, that the methods appear efficient, and that the final result seems good. And last but not least, the work was evidently profitable to the contractor.—The Editor.

A siding was laid out from the Chicago, Aurora & Elgin Railroad, an electric interurban line that afforded a material supply, where this road crossed 1st Ave. in Maywood. This siding approximately paralleled the main line at a clearance of about 75 ft., and dead ended at about the street, which gave access to the job. This ground was leased for the purpose from the Public Service Co. of Northern Illinois, the corporation holding that tract of land for storage requirements. The batchers were then erected between the siding and the main line. Stock piles were built up on the opposite side of the siding from the batchers.

Trains of eight cars of aggregates and two cars of cement would be brought in at the start of the day and spotted on this track after the removal of the empties of the previous day. These trains were so made up that the gravel cars followed the locomotive, then came the cars of sand, and the cars of cement were at the end of the train. Backing into this plant, the cars of cement would then be spotted at the dead end of the siding, the cars of sand would be opposite the sand batcher, and the cars of gravel would be likewise conveniently spotted. Individual cars would be spotted during the day by means of a 2-batch truck loaded with gravel hooked to the car with chains.

The aggregates were loaded into the bins or stockpiles from the cars or into the bins from the stockpiles by means of a ¾-yd. Northwest crane equipped with crawler treads and a ¾-yd. Williams clamshell bucket. This crane took its stand on the stockpile side of the siding and had plenty of reach to serve its purpose.

With this arrangement of plant, an empty truck could pick up its load and depart for the job without confusion and without interfering with following empty trucks. They would approach the yard along 1st Ave., make a right turn and proceed to a point just beyond the 40-batch gravel batcher, then make two right turns and come to a stop under the gravel bins. After receiving this part of the load, the truck would proceed in a straight line toward the avenue, coming to a stop under the 70-batch sand bin long enough to take on sand, and then continue in the same direction until opposite a cement car. Here the sacks of cement would be emptied onto the load, and the empty sacks thrown to the far side of the truck onto a pile on the ground for baling while the truck proceeded to the street,

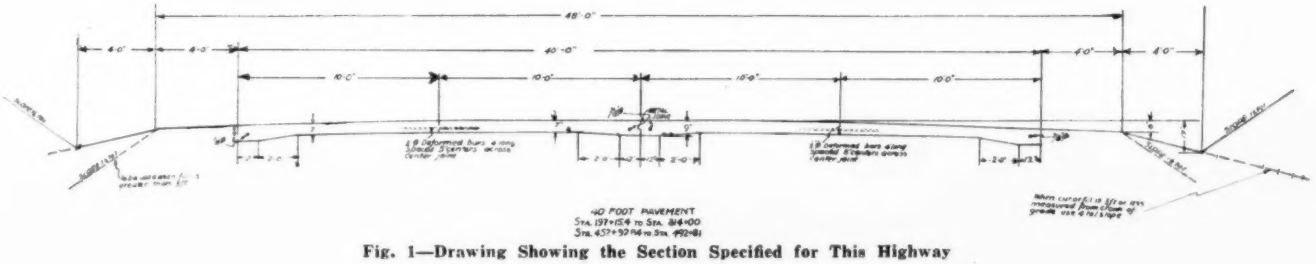

Fig. 1—Drawing Showing the Section Specified for This Highway

Fig. 2—General View of Batching Plant Looking Toward the Cement Cars

Fig. 3—The Trucks Received the Cement From the Cars

Fig. 4—Heavy Grading on the Village Contract Was Done by Shovel

made a left turn, and moved off for the paver.

Organization.—This part of the work utilized, besides the equipment already specified, the services of seven out of the total number of trucks given later in this story. The crew consisted of the following men:

1 Foreman
1 Inspector
1 Crane operator
1 Oiler
2 Laborers, car
1 Gravel batcher
1 Sand batcher
4 Cement hands
1 Sack baler
7 Drivers
1 Watchman

The inspector, of course, was a state employee, while the other men were em- used on this job, with one exception, were Hug single batch self-dumping trucks. One double-batch truck was used. In dumping these trucks, the dumpman trips a lever, and the force of the truck backing against the paver skip, aided by gravity, dumps the truck.

Grading.—While most of the job was graded by means of elevating graders, the extra-contract grading being done when the job was visited for the second time was accomplished by a ¾-yd. Northwest gas shovel, with crawler treads, loading onto batch trucks. The excavated dirt not needed for shoulders was taken to the nearest dump, less than a mile away, while that needed for the shoulders was dumped in place.

Fine grading was done by means of a 2-up Western blade grader, aided by a slip scraper when necessary. This latter work was done without an extra team or driver, as the team on the grader would be unhitched and hitched to the slip scraper when that class of work had to be done. This blading was followed by final grading with a subgrader pulled by a Best 60 tractor operated by the same grading crew. This was followed by a rolling with a 4-ton Austin Pup gas roller. The tractor operator ran the roller as well. This grading crew and equipment turned out a good job with the hard clay soil that was encountered. Some difficulty was experienced after a heavy rain, since the clay tended to lump up when wet, and become very hard when dry. Uneven drying lead to difficulties as well. The grading organization was as follows:

1 Foreman
2 Truck drivers
1 Shovel operator
1 Shovel oiler
1 Grader driver
1 Grader operator
1 Tractor operator
1 Subgrader operator
5 Subgraders (also dig form line)
2 Form setters

The Mixer.—The paving work was based on a Koehring 27-E paver, with a subgrade planer attachment. The mixer was fed by batch trucks from the batch plant already described. When the work was observed, one 20-ft. slab had been laid and cured, so it was possible for the trucks to utilize this pavement until they reached the paver, when they would be backed down onto the subgrade, discharge their load, and return for another batch. A 1 minute mix was specified for each 6-bag batch, and since the drum was kept revolving and no more time was wasted between batches than was necessary, the actual mixing time per batch when taking charging and discharging time into consideration was about 1½ minutes. About 6 gal. of water were used per sack of cement, or a total of 36 gal. per batch. With the mix used, this gave a concrete that appeared well proportioned and mixed, and of just the right consistency for the finishing machine.

Finishing.—Finishing was mostly done by means of an Ord finishing machine, with specially designed smoothers and templets going over the work twice and keeping right up to the mixer. This was followed by a slight amount of floating and by two courses of belting. The Ord finisher was equipped with additional set of flat wheels to run on edge of first 20-ft. slab in the laying of the second 20-ft. slab. The paving crew handling the mixing and the placing of the concrete was as follows:

1 Foreman
1 Mixer operator
1 Finisher operator
1 Dump man
2 Steel and planer men
3 Puddlers
1 Edge spader
2 Finishers
1 Helper
1 Handy man

Curing.—The curing specifications provided for a covering of wet burlap for the first 24 hours, and this to be followed by the surface application of calcium chloride at the rate of 2½ lb. per square yard. This work was done by one man, who spread and wet the burlap, who spread the chloride by means of a chloride spreader, who cleaned the pavement and kept it clean, and who rubbed down high places with the carborundum brick when directed by the inspector. He was helped by one man from the subgrade crew when necessary, particularly for handling the burlaps.

The pavement was checked for profile by means of a "Bumpometer," the device recently invented by the District Engineer. This handy little device registers bumps and depressions by means of a movable third wheel that makes an electrical contact and rings a bell when an unallowable bump or depression is encountered. It is illustrated herewith.

Truck Equipment.—The summation of the equipment required and used on this job would hardly be complete without an account of the fleet of motor trucks that had to be provided. Without an adequate truck fleet this contractor would find his work seriously impeded, just as would any other contractor working on a job theoretically or actually isolated from the material and labor transportation facilities of the large city. On this job the materials were received by rail at a short distance from the work. The men were kept in camp had to be transported to and from the work each day. Supplies for men and animals were delivered to the camp from the nearest markets. Small tools must be supplied, and gasoline and oil must be secured for the

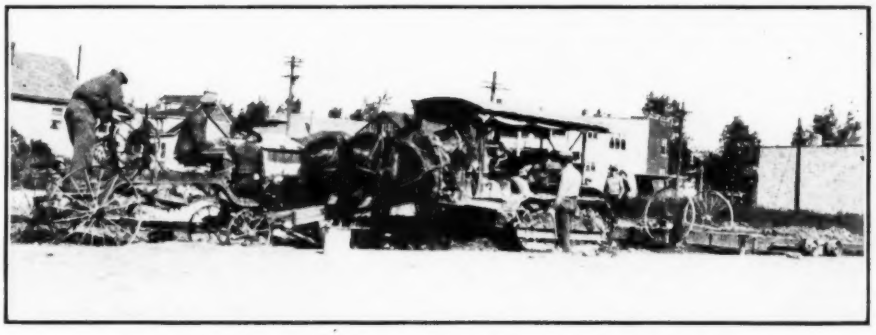

Fig. 5—The Subgrade Was Next Bladed and Then a Subgrader Was Used

Fig. 6—This Roller Then Prepared the Subgrade for the Concrete

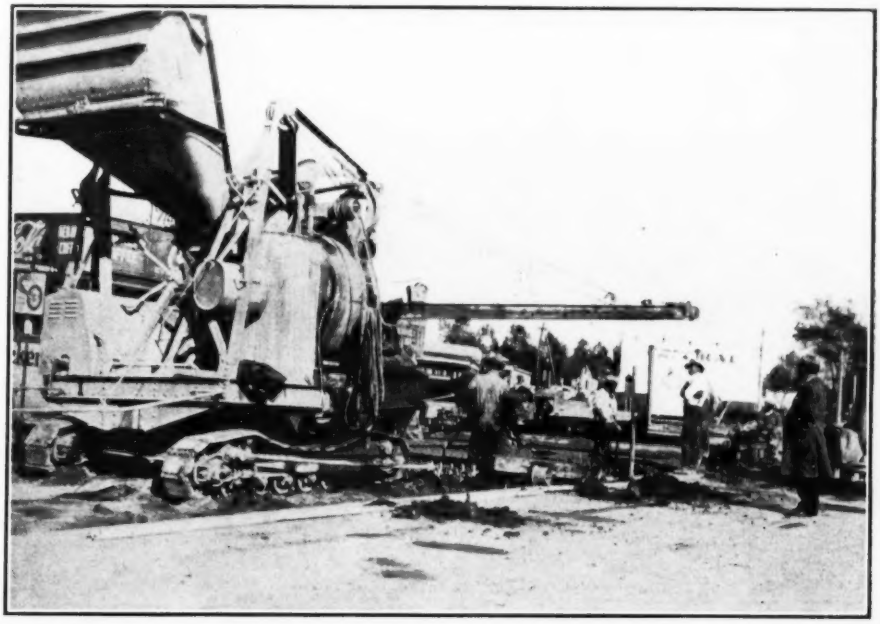

Fig. 7—The Mixer Was Provided with a Subgrade Planer to Take Out the Ruts Left by Trucks and Paver. Note Distance Between Finishing Machine and Paver

Fig. 8—This Ord Finisher Compacted and Finished the Slabs Under the Watchful Eye of the Foreman (Right)

equipment. Some of the employees own their own cars.

The following gives a list of the automotive equipment used on the work:

13 Hug single batch trucks
1 Hug double batch truck
2 White service trucks
2 Ford service trucks
1 Ford dump truck
1 Dodge roadster
1 Ford runabout

Due to the great amount of grading work being carried out from the camp, a separate grading camp was maintained. Here a total of 85 head of mules and horses were maintained during the peak of operations. This one contract utilized as many as 30 head at one time, and 17 head were used on the day the job was visited. One team was used on subgrading, one team on shoulder work at the same point, and the rest were used on shoulder work further up the line where the pavement had been completed. On this latter part of the work, ditches were cut with elevating graders and fresnos, and a labor force of about 20 men was used. These men included teamsters, a grader operator, a tractor operator, truck drivers, slopers, and the other classes of labor needed on such work, all in charge of a foreman.

Those Responsible.—The work was done for the State of Illinois, the United States, and for the village of Maywood under state supervision by the J. J. Dunnegan Construction Company, for which D. H. Crawford was superintendent in charge of the job. The state was represented on the work by G. N. Lamb, District Engineer; O. J. Frost, Resident Engineer; and J. R. McCabe, Junior Engineer.

Fig. 9—After the Concrete Would Bear the Weight of the Inspector This Bumpometer Was Used to Detect Bumps and Hallows That Would Have to Be Corrected. It Revealed That the Job of Finishing Was Well Done

Magnetic Scrap Collector for Road Maintenance

What is believed to be the first magnetic device especially designed to serve in highway maintenance is reported by Professor H. B. Carpenter, Director of the Engineering Experiment Station, State College, Pullman, Wash. According to The Highway Magazine, this equipment, designed by H. J. Dana of the Experiment Station, will pick up nails and heavier pieces of iron from a height of 6 in. or more. When lowered to within 2 in. of the ground it loosens and collects nails embedded in loose gravel or partly embedded in compacted material.

This equipment has two 4-ft. magnet bars which sweep a strip 8 ft. wide. It may be operated with one, two, or three magnets, depending on the road conditions. To provide the electric power needed for operating these powerful magnets, a special Ford-engine-driven generator has been assembled on skids so that the entire equipment can be loaded on any truck ready for operation on short notice.

Surprisingly large quantities of metal are picked up by this equipment on an ordinary road. In the course of a few miles not only nails but speedometer cables, small tools, and many other articles likely to be lost from motor vehicles or wagons are collected. This motley collection ranges from 2 to 10 lb. or more to the mile of road covered. The most plentiful crop of nails is found in city alleys and in neighborhoods where buildings have been recently torn down, but there seems to be no stretch of highway which does not give up a large number of iron or steel objects, most of which are apparently just made for puncturing tires.

Forest Highway Funds Allotted to Alaska Projects.—The programming of an additional $55,000 for work on Forest Highway projects in Alaska during the current fiscal year has been approved by Acting Secretary Dunlap of the United States Department of Agriculture. These supplemental funds will be used for reconstruction work on the Glacier Highway at a cost of $11,500 and for the reconstruction of bridges on the Kenai Lake Highway at a cost of $23,500. The balance will be spent in location surveys on Alaska forest road projects and on administrative and engineering investigations. The $55,000 just allotted is in addition to that which had already been programmed to Alaska projects for the present fiscal year ending June 30, 1928. The acting secretary also approved the expenditure of $5,000 of Federal Forest Highway funds for the location survey of a number of road projects in the State of Washington.

The Technique of City Management

Policies That Make the Successful Manager Described in Paper Read Before the International City Managers Convention, Dubuque, Iowa, September 14, 1927

By R. W. RIGSBY
City Manager, Durham, N. C.

The city manager profession has developed a technique that challenges the attention of every wide awake student of government and stirs speculation as well as research into the causes underlying the notable successes in this field of service. This profession has gained recognition and adoption in some of our larger cities but its technique has been purified in the ferment of public opinion in the smaller towns of the United States and Canada. We shall perform a distinct service if we can glean from our experiences those intangible qualities that have spelled success.

Throughout the history of the city manager we have heard him likened to the business executive with his board of directors. It was easy for the lay mind to understand that comparison. The comparison of this form of government with business organizations has quickened the pulse and brightened the hope of many discouraged citizens who had been the victims of unbusinesslike and inadequate municipal government.

But after the voting comes the city manager, who must learn by bitter experience, if he does not already know, that the likeness of the council-manager form of government to business organizations is subject to a very broad interpretation. He finds a different relationship existing between the citizens and council than exists between stockholders and directors in the ordinary corporation. The relationship of the administrative personnel to the public and the council also presents a problem which cannot be solved by searching the methods of ordinary business administration.

High Turnover.—Maybe this accounts, partly at least, for the fact that there has been a labor turnover among city managers that in business would be viewed with alarm. And though we realize that several capable men have retired voluntarily from the profession, for reasons which did not detract from their qualities as city managers, the great majority failed because they did not possess those administrative qualities that are necessary to combine the influences and hold the confidence of a community.

The successful city manager adjusts himself to his position in a community with the least possible notoriety. He realizes his duty as chief administrator of city affairs does not include his being a social lion or an object of curiosity. He approaches the necessary reorganization of departments and the handling of personnel with discretion and eliminates any attitude of radicalism or personal feeling. He is thoroughly human, is attentive, approachable and has a broad understanding or human nature and its reactions.

He forms friendships as a result of his attitude of friendship. He expresses and responds to friendliness, but is quick to detect that false friendship which precedes a request for special service. He does not waste his energies seeking revenge for wrongs even though most unjust, but tries to eliminate from his thoughts all grudges before they become a burden and hindrance to his progress. Uderlying all his decisions and in the solving of the many problems of administration there exists a patient adherence to the principle of right, even though it may seem so easy to do otherwise.

The Newspapers.—He is frank and ready to talk with newspaper reporters but seeks to impress upon them the news and not his personal connection with the news. He avoids strenously newspaper controversies and seeks to correct wrong impressions without stirrring up undue strife by personal correction. If a manager has been conscientious and effective in his work and a community permits his work to be misinterpreted and maligned, without refutation outside the personal refutation of the manager, then it is quite evident that community is asleep and neither deserves nor will hold the services of a good man.

The successful city manager must divide his responsibility among his department heads and should have confidence in those heads to handle their respective duties. He must avoid an attitude of suspicion and be a source of encouragement. He should not assume the critical air but attempt the attitude of interest, and he should make it genuine. The executive who doesn't have a genuine interest in and sympathy for the men in the departments, who come in contact with knotty problems of irate citizens, is going to be hampered by a reflected feeling of resentment from those employees. He should have that poise and spirit of cooperation which elicits confidence on the part of employees yet will not permit liberties to the detriment of the service.

Departmental Relations.—In dealing with department heads and other employees he finds there is considerable to be gained by often going to their offices instead of being too much the center around which revolves the affairs of the city. There appears no good reason why a manager should practice the formality of having department heads come at regular periods to his office for instructions. If department heads are not well enough trained to operate their departments, not only as one unit of city service, but in cooperation with other departments, without constant admonitions and direction from the manager, there is an evident lack of technique. Let the department heads assume responsibility and show initiative. The manager is the oiler of the machinery. If he hasn't it well enough oiled to leave for a month with confidence that it will run smoothly he will probably find that he has become a cog in the machine and it will sooner or later drag him down. The successful manager acquires perspective by freeing himself as much as possible from the routine duties of operation and is thereby enabled to coordinate more effectively the work as a whole.

He does not argue with his various executives. He gains nothing by useless arguing and above all he does not have to argue. He does not deal in the ordering business by sending executive orders to various department heads, but rather makes requests courteously and gives credit where credit is due. The "fire eaters" has no place in an organization and the manager who thinks in terms of putting over his ideas, regardless of consequences, has restricted his possibilities measurably as a success.

Directing Progress.—Some men well qualified in many respects have assumed the attitude as city managers that they should put over a progressive program and have worked for this so intently that they find themselves out of tune with the community. They get so far ahead of the procession they can't hear the band. The successful city manager assumes an attitude of openness to suggestion. He is glad to get the ideas of others. He analyzes the needs of a community and recommends with caution. He tries to be broad in his attitude toward all branches of public service and does not unbalance his administration by leaning so strongly toward one phase of service that others are neglected. We have had examples of this condition where fairly capable men became so immersed in their desire to develop certain phases of city service that they seemed to forget

other phases, thus making unbalanced progress.

He treats the public with courtesy and gives no cause for criticism because of the conduct of his private life. If he posts office hours he maintains those hours and so long as he's in his office and is not engaged in a conference he will not refuse to see a citizen who requests an audience. He will not refuse to talk to anyone that has a legitimate request to make. The city manager, who can get the other fellow's viewpoint and agree with him without sacrificing any material principle or poise, is an artist of the highest type.

The manager must handle many perplexing problems with the public either personally or through letters and the successful city manager puts the problem upon principle and justice, not upon personal favoritism or personality. If there ever was a snare and a delusion it is one where a city manager tries to settle problems on any basis except that of justice and equality. He must know neither wealth no poverty in the distribution of public service.

The City Council.—The city manager, as the open channel between the administration and the council, should keep that channel so easy of access for all inquiry and direction as to obviate the possible tendency of council members going direct to administrative officials with requests and directions that might undermine the very foundations of successful management. The successful city manager is always frank and honest with the council. He lets them feel his active interest in all affairs of the city. He recommends what he believes to be for the best interest of the city. He keeps the council members well informed as to important affairs but does not burden their minds with ordinary administrative matters unless they inquire concerning them. He gives the council ample time to consider all matters he may have recommended and is particular not to insist upon his ideas. He realizes he is an administrator and not a legislator.

He uses his right to speak at open council meetings with the greatest caution and holds himself to facts without dealing in personalities. He realizes his duty is to carry out the council's policies with promptness, courtesy, and the proper attitude. He studies the council members and is able to anticipate their reactions to different problems. In this way the greatest progress can be accomplished with the least effort. As much as possible, he will suggest the solution of problems in such manner as not to embarrass members of the council's before the public or to permit malicious misrepresentation.

He gives the council the credit for accomplishments in city progress. The same psychology occurs here as in relation to the administrative officials. He seeks to give credit to the other fellow. No man ever gave away half as much as he got back in return for patting the other fellow on the back. Why should a manager who is thoroughly conscientious in his desire to give service be envious because some one else gets credit for something for which he was only partially responsible. The successful manager assumes an attitude of gratitude for every thought or deed which promotes good government and above all he does not spend his valuable time trying to claim credit for himself.

Adhere to Code of Ethics.—In his attitude of frankness and service to the city council the manager should maintain a poise and purpose which will leave no doubt that he is guided by a code of ethics. And, if there is any deliberate action upon the part of a council which tends to pervert the form of government, the only thing to do is resign.

As a matter of fact the manager who has that interest in his profession and in good government that he will resign before he will see either placed at a disadvantage is the same manager that is the most valuable in that position. The manager who is fearful he will lose his position is most likely to lose it and the one who is ready to resign rather than be a part of perverted government gains in the long run.

He is particular to maintain a cheerful attitude and one of genuine enthusiasm in his work. He does not let any one go away with the feeling he has not had fair treatment. He never assumes the attitude of final arbiter in any matter for which he is not solely responsible but gives each citizen the idea he can always appeal to higher authority. He takes time to explain why certain policies have been set and assumes no superior attitude. A city manager is a business executive and not a patronage player, and he holds himself steadfastly to polices of equality to all and special privilege to none.

He must have vision and get others to see the vision. He must be confident of his ability to manage the affairs of a city yet recognized his dependence upon cooperation and organization. The manager who sets with his nose in a bunch of figures or is immersed in a flood of details of city business will never achieve the proper technique. He becomes so filled with material considerations he loses touch with the mental forces which control all communities. His business is that of an artisan who builds the best service and facilities the community thought will approve and stand back of. He is not a reformer to change the habits and customs of the people.

Cost of Water and Revenue

The accompanying table from the 1926 report of J. E. Gibson, Manager and Engineer of the Water Department of Charleston, S. C., shows the cost of water supplied to consumer and the revenue derived from it.

It will be noted that the average cost of water, including all operating expenses, sinking fund, depreciation, interest on bonded indebtedness and interest on monies invested in plant from surplus account, and extraordinary expenses due to lowering and repairing mains and services on account of repaving, is $148.65 per million gallons, or a fraction under 15c per gal. The income from the sale of water amounts to $163.48 per 1,000,000 gallons or a little over 16ct per 1,000 gall.

Mr. Gibson states in his report that the plant is now operating at nearly its maximum income efficiency in that the consumption is very near that for which the plant is designed; namely, 6½ million gallons per 24 hours. There is, therefore, no idle investment in additional water supply, to take care of the growth of the city upon which interest must be earned. This high income efficiency cannot continue as we must very shortly obtain additional water supply, and necessarily this supply must look considerably in advance of immediate needs, and the margin of income now obtained will be required to pay interest on the cost of this extension.

COST AND INCOME PER MILLION GALLONS OF WATER DELIVERED TO DISTRIBUTION SYSTEM, — 1921 TO 1926, INCLUSIVE

ITEM	1921 Item	1922 Item	1923 Item	1924 Item	1925 Item	1926 Item	Averages Item
Operation and Maintenance Mains	$ 7.60	$ 7.38	$ 9.80	$ 9.35	$ 8.95	$ 9.50	$ 8.76
Operation of Plant, including Fuel and Purifiers	38.20	32.42	34.10	34.35	30.90	31.60	33.60
Maintenance of Machinery, Buildings and Filters	7.65	2.58	8.15	6.90	4.10	4.85	5.70
General Offices, Clerical Assistants, Insurance, Legal and Office Expenses	19.10	17.55	20.45	21.90	20.40	21.40	20.14
Sinking Fund and Depreciation	17.10	16.67	19.40	20.30	19.60	19.05	18.69
Interest Bonds, Loans and Taxes	32.35	34.45	38.35	39.40	37.40	35.60	36.26
Interest on Monies Invested in Plant from Earnings	8.60	11.38	16.20	19.35	21.20	22.95	16.61
Extraordinary Expenses, Lowering and Repairing Mains, Account Repaving, etc.	3.15	9.25	7.15	13.80	11.70	8.30	8.89
Total	$133.75	$131.68	$153.60	$165.35	$154.25	$153.25	$148.65
Income from Sale of Water	$155.35	$151.90	$166.30	$174.85	$167.50	$165.00	$163.48

Automatic Control of Traffic

Recent Developments Described in Paper Presented Sept. 28 at 16th Annual Safety Congress

By K. W. MACKALL

Any discussion on the subject of the control of traffic by electric traffic signals, or by any other means, must be of vital interest to the National Safety Council, since its activities are solely directed toward the elimination of accidents.

It is in this phase of the subject that we are most interested, since it is of the most importance. City authorities may assign other motives for the installation of signals, and yet there is no denying the fact that signals are actually installed today for the very same reason that the traffic squad was created—namely safety. Other results may be, and usually are, accomplished by the installation of a well-designed signal system, but were it not for the prime consideration of safety there would be no signals, nor would there be any traffic squad. It was owing to the desires of the municipalities to protect life and property that the traffic squad was created—which also sponsored the installation of the modern traffic signal system.

Most of us think the traffic squad was created to handle the automobile problem, but I can assure you that such was not the case, for many cities had traffic officers before the automobile became a factor in our daily lives.

It is quite true that the automobile enhanced the problem and caused the enlargement of existing traffic squads. As the traffic problem became more acute, traffic officers were given mechanical aids, such as whistles and semaphores, but even with these aids, the traffic officer was unable to cope with the problem because of his limited vision and complete lack of coordination with traffic officers at adjacent intersections.

Officer Inefficient on Broad Scheme.—Let me make this quite clear—I do not mean to imply that the existing traffic officer is inefficient. As far as one particular intersection is concerned, the intelligent traffic officer is far better than the best traffic signal, because the traffic officer can observe traffic conditions within the range of his vision and act accordingly. It is only because he is concerned solely with his own particular intersection that he becomes inefficient in the broad scheme of traffic control. He may clear his own particular intersection most admirably and yet do a very bad job of traffic control since he may send traffic to adjacent intersections which are not ready to handle it.

In the original scheme of things, the traffic officer's job was not only the direction of traffic, but he was also a bureau of information and of great assistance to the aged and infirm and was more or less able to move around and enforce traffic rules. He was really efficient. The dense traffic created by the automobile turned the human traffic officer into a human semaphore—an automaton, with no time to do other than direct—and oftentimes dodge—vehicular traffic. He could not give information, since no one could get to him, and he dared not leave his post in the center of the intersection to assist anyone or even to enforce traffic regulations. He blew his whistle and sometimes the violator stopped—sometimes not.

Reasons Why Signals Are Used.—Let me, for a moment, briefly review the reasons why signals are installed and the results to be accomplished. The reasons for the installation of signals are three and they are very simple. They are tabulated below in the order of their relative importance.

1. Safety.
2. More economic utilization of the police force.
3. Expedition of traffic.

Analyze these three reasons carefully and it will be seen how closely they are inter-related. The first—safety—is of the utmost importance and were it not for this consideration of safety to life and property the police force would not be involved at all.

The third—speeding up of traffic—is really the result to be accomplished, if it can be done with safety.

Granted now that the result to be accomplished is the speeding up of vehicular and pedestrian traffic with safety—what is the best means of accomplishing this very desirable result? If it were actually possible to accomplish this result with traffic officers; unaided by other means, such as traffic signals, it would still not be economically possible to control traffic solely by means of traffic officers. We are past the days when a few intersections in the heart of a city's business district constituted the "traffic problem." The problem today is almost the entire city and it will gradually become more and more acute until the point of automobile saturation is reached.

Unfortunately, the city fathers and planners of other generations could not foresee our problems of today and plan our streets accordingly. Only a few cities—such as Salt Lake City, Utah, and Birmingham, Ala., were laid out with thoroughfares sufficiently broad to handle modern traffic, and even with their broad streets the use of a traffic signal system materially assists in accomplishing the desired result—expedition of traffic with safety.

The economics of the problem are quite simple and they are convincing. An intersection of signals will cost between $700 and $3,000, depending upon the type of signal and the method of installation.

The expense of a policeman for an 8-hour shift, including his salary, his supervision and his maintenance is upward of $3,000. For some intersections this means $6,000 per year when an officer is required for two shifts. A safe average for signal cost is $1,500 per intersection, which means that for the cost of one traffic officer, two intersections of signals may be had. After the first cost of the signals has been paid, there is only the maintenance cost of say $150 per year. Thus, 20 intersections of signals may be maintained for what it costs to keep one traffic officer.

Please do not misunderstand me. I am not recommending the complete signalization of a city and the elimination of the officer. With human nature what it is, that would be impossible. I am merely pointing out the economics of the thing and showing how a city may economically spend its budget money for greater protection to life and property. Signals at all bad intersections, traffic officers at the worst ones and officers mounted on motorcycles patrolling all others. This will solve the problem economically. No city has sufficient funds available to place traffic officers at all bad intersections.

Refinement in Timers.—The subject of this paper is "Recent Developments in Automatic Control." To the engineer, designing control apparatus, the word "recent" means the thing he hopes will solve the problem. For he is looking for something better. That may seem strange, but it is, nevertheless, a fact. The development of control apparatus has been very rapid, during the past two years and will, in all probability, be more rapid during the next two. It is not the purpose of this paper to enter into a description of the mechanical and electrical features of timers, but rather to describe briefly what degree of flexibility may be had.

Early timers performed a set traffic cycle without any variation. Then followed a timer capable of performing two set cycles. In order to use them an accurate traffic count had to be made and it had to be predetermined just how many seconds traffic should be permitted to go in each direction. These were followed by timers which could be varied at will both as to total period of the traffic cycle and the split

in each direction, keeping the amber of change period constant. This seemed to be all that was needed—and in fact a timer of this nature will meet most problems.

However, a further refinement in timers has been developed during the past year and it is the last word in flexibility, whenever such control is really needed. This latest timer will vary the north-south GO period at will, it will vary the amber period between the north-south and the east-west GO periods at will, it will vary the east-west GO period at will, and it will vary the amber period between the east-west and the north-south GO periods at will. With this new timer any of these four variations may be made independently of the other three, without the use of tools and without shutting down the system. Surely that is all that will ever be required.

The mechanism to accomplish all this is small and pretty reliable. There will be improvements in design—that is to be expected. The same engineer who designed such a mechanism will not be content until it has reached a stage of perfection equivalent to a grandfather's clock.

So much for the timer itself.

Types of Control Systems.—Now for a moment let me explain systems of control and their relation to the broad scheme of traffic control.

During the last year or two there have been many improvements in the control apparatus for signals and even more particularly in the methods of control. I shall briefly review these improvements and endeavor to point out when the various systems of control may be applied to advantage and possibly predict the trend of future development. In order to make the matter perfectly clear, let me name the various systems of control now in use together with a description of each. They are:

1. Synchronous control.
2. Progressive or modified progressive control.
3. Co-ordinated control.

These types of control have very definite meanings, at least to traffic signal engineers, and it is important that each system be thoroughly understood, together with the accomplishments and limitations of each system.

Synchronous Control means that traffic moves simultaneously on all north and south streets while all east and west traffic stops—followed by the simultaneous movement of all east and west traffic while north and south traffic is stopped. Such a system is accomplished by a very simple timing device, located at a central control point which may be varied as to total period of the traffic cycle and the split in each direction. The outside wiring is very simple and no controls are required at each intersection. Synchronous control may also be accomplished with synchronous motor timers located at each intersection, dispensing with the inter-connecting signal cable. However, with this latter method, it is not possible to vary the total period of the traffic cycle. Such timing devices, when connected to a common A. C. Supply line, will remain in step indefinitely.

Progressive Control is the simplest method of attempting to provide a continuous movement of traffic without the stops that are inherent in synchronous control. An ordinary synchronous system may be changed to progressive control by simply reversing the signal colors at the beginning of each traffic block. This is a straight progressive control system and is open to the objection that the split in time between north-south and east-west timing must be even. The total period may, however, be varied at will. The more up-to-date modified progressive control does away with this limitation and provides the same flexibility as the synchronous control. This may be accomplished by a duplicate set of interconnecting cables, connecting the signals of each alternate traffic block to corresponding cables, or by using a special progressive timing system consisting of a central station timer and subcontrols at each intersection. If the variation in the total period is wanted progressive or modified progressive control may be accomplished with synchronous motor controls at each intersection, dispensing with the inter-connecting cables.

Co-ordinated Control is the perfection of timing since it gives the utmost in flexibility. So far as I know, it originated in Chicago, and has since been used in several other places. With such a system the total period of the traffic cycle may be varied at will and the split in time between the north-south and the east-west directions may be varied for each and every intersection, if desired. The only limitation being, that the total period of the traffic cycle must be the same for all intersections. In Chicago this system of control was accomplished by means of a very elaborate central station timer and separate cables running from each intersection back to the central control station. This made a rather expensive installation. Since the system was put in traffic control engineers have been working on the problem and have developed new control apparatus which will accomplish the same result with a very simple central station controller and simple sub-controls at each intersection, dispensing with all but a single cable between intersections.

Improvements in control systems are coming not so much in results accomplished but in the methods of accomplishment, such as the reduction or total elimination of connecting wires.

Where the Traffic Engineer Comes In.—The problem before any city is, therefore, the selection of the proper system of control to fit its needs. Offhand, a city would be sure to select the co-ordinated system of control, owing to the extreme flexibility. Unfortunately the question of first cost and maintenance expense is a troublesome problem for most cities to face and the selection must only be made after a very careful study of conditions. The speed and density of motor vehicle traffic, the speed and number of street cars, the volume of pedestrian traffic, block lengths, width of streets, boarding platforms for street car patrons, right and left turning vehicles, parking, etc., all affect the selection of a system. All of this must be nicely balanced against initial cost and maintenance—and—against the phase of ever changing volume of traffic throughout the hours of the day—remembering always that the result to be accomplished is speed with safety.

It may readily be appreciated, then, that there is a real need for each city to employ a traffic engineer, whose sole duty is to study the problem from every angle. It is not a part-time job, nor is it a problem which will be solved for any fair-sized city in a day, a week, or a month. It is a permanent job for an expert.

Let me cite an extreme case where the most elaborate system of co-ordinated control will not work one bit better than the simplest synchronous system. On a narrow street, carrying one lane of traffic in each direction; where, due to parking, all traffic must follow the back of street cars and stop with the cars. The street car schedule, with its extremely variable periods of loading and unloading, will absolutely govern the speed of all traffic and upset any prearranged attempt at the continuous movement of traffic.

The one cardinal priciple necessary for the continuous movement of traffic is the presence of at least one lane of moving traffic in each direction—a lane of traffic not affected by street car stops and not affected by other cars pulling into and out of parking space. Unless there is such a lane for continuously moving traffic, no elaborate system of control will work.

Street Loading and Traffic Control.—One of the things most overlooked in traffic control is the number of vehicles in any given block. It is thought by some that the full block is ideal, but such is not the case. Let us assume for a moment a street with 400-ft. blocks and cross-street widths of 60 ft. from property line to property line, making a running distance of 460 ft. per block. During the rush hours, when streets are taxed to capacity, an average speed of 12 miles an hour is good and 15 is the most to be hoped for, though the usual result is much less. To illustrate the point let us take 12 miles per hour as the average. If there are five vehicles in line waiting at each intersection the speed of getaway of these five vehicles will control the running speed of the street. Each

standing vehicle takes approximately 15 lin. ft. of street and takes approximately two seconds to get started. At 12 miles an hour the first car in line will travel the 460 ft. in 26 seconds; it will travel 460 ft. minus 75 ft. (the space consumed by the five waiting vehicles) in slightly less than 22 seconds, or will before the fifth car in line has started. This applies to synchronous control of traffic.

With a continuous movement of traffic afforded by progressive or co-ordinated control the street loading is about the same. Vehicles moving continuously in line at 12 miles an hour will string out, each one occupying about 35 lin. ft. of space. Since, however, with the progressive or co-ordinated systems each alternate traffic block must be entirely free from running cars to allow for cross traffic, the figure 35 ft. must be doubled, thus allowing 70 lin. ft. for each vehicle. Seventy feet for vehicle will permit only six cars per block of 400 ft. (Actually there would be 12 cars in every other block.) It would, therefore, seem that there is no great advantage for any system so far as effective utilization of street length is concerned. Actually, however, the average speed of cars under a co-ordinated system will be better than 12 miles an hour, particularly on streets which do not carry street cars, but the street loading of one car for every 70 lin. ft. is seldom bettered, since at higher speeds, vehicles require more rather than less space.

Uniform Traffic Laws Needed.—The crying need of the day is for uniform traffic laws and many states are now at a point of passing state-wide laws to apply to the control of traffic by means of electric traffic signals. The creation of such laws is a laudable ambition which, however, is utterly impossible of accomplishment, except at a sacrifice of individual city efficiency and safety, merely because what is excellent for one city may bring chaos in another and what may be accomplished on wide streets, cannot be done on a narrow street.

Let us consider only two of the points which are under discussion in the formation of uniform traffic laws. First—when and how should the right turn be made? Second—when and how should the left turn be made? There is enough disagreement about these two points to show the uselessness of endeavoring to create uniform traffic laws. And yet uniform traffic laws are most desirable.

The right turn is made with the green light only or with either the green or the red light. Some cities permit it at any time—even when the amber light is showing. It is quite easy to say that the right turn should be made only when the green light is showing, and yet in some cities, like New York City with a very large number of very short blocks, traffic would soon become completely blocked were this rule enforced at all intersections.

Under ordinary conditions, with reasonable length blocks, it is far safer to permit the right turn only when the green light is showing—safer for pedestrian traffic and safer for vehicular traffic moving at right angles to the turning vehicle. The best law that could be possibly made for the right-hand turn would be to permit it only when the green light is showing and only when the turning vehicle is in the lane of traffic nearest the right-hand curb. When the physical layout of streets demands that the right turn be permitted on the red light also, that particular intersection should be clearly marked as an exception to the general rule.

The right turn is relatively simple—since there are only three or four ways in which it may be made. The left turn, however, presents a far more difficult problem. During the careful study of traffic, as governed by the three-color traffic signal, I have found 17 different methods of making the left turn. I'll not enumerate them but instead I'll cite a particular street condition which is all too frequently found in our cities and then apply to it the only rule for the left turn; and the right turn, too, for that matter; which may be applied.

Assume a street which has just sufficient width for one lane of moving traffic in each direction. It may be a 20-ft. street without parking or street cars, a 40 ft. street with parking but without street cars, or a 60 ft. street with parking and a double line of street cars—all provide just sufficient road width for only one line of moving traffic in each direction. On such streets, of necessity the left turn must be made with the green light. No special signal for the left turn may be used, for there is no place in which to store the cars temporarily awaiting any special left turn signal.

With this in mind, the only uniform law which may be applied to the left turn is to permit it only with the green light and from the lane of traffic nearest the center of the roadway. At that, such a law is reasonably safe, since the driver of a vehicle, approaching an intersection where a green light is displayed, has only one thing to guard against and that is the possible left turn made across his path from the opposing parallel lane of traffic. And yet in a city like New York City, with its one-way streets, it is not the best nor the safest. New York makes its left turns when the north and south traffic is stopped and thus all left turns into and out, of the one-way streets are made without cutting any lane of traffic.

Standardization of Sequence of Color.—Perhaps the place where a unform traffic law is most needed is in the standardization of the sequence of color—the color of the lights to be used and the order in which they are to be displayed. At the present time there are about 20 different color sequences in use, some of which are good and some are bad. There is much debate at the present time over the amber light—whether or not it is necessary or even advisable. This argument immediately divides the signals into two main classes, viz.: the three-color and the two-color signal. It is not the province of this paper to take sides in this argument, but rather to analyze the claims of both, hoping that the immediate future will settle the point.

Regardless of the number of lights per signal it is universally argreed that traffic shall move on the green light and stop on the red light. It is only as to the change period that there is any disagreement.

There is a sharp disagreement between those who advocate the three-color signal and those who advocate the two-color signal. Those latter claim the amber light is unnecessary—and in some cases confusing.

Pavement Markings.—I would like to bring out one other point to the attention of this meeting and that has to do with the proper pavement markings, particularly at intersections. Paint is a wonderful aid to safeguarding traffic. On streets where there are no street cars, the marking of the center line does wonders to align traffic and keep vehicles on the proper side of the roadway.

Pedestrain cross-walks should be clearly defined with two lines, one in line with the curbing and the other in line with the property line. Cross-walks so marked will be more generally respected by both stopped and moving traffic.

One of the great delays in traffic is due to the incorrect alignment of stopped vehicles at intersections. Streets wide enough for two lanes of traffic in each direction may be rendered less efficient by bad alignment. If the first car in line straddles the two lanes, the second car must wait behind it. If the first car goes into the proper lane the second car will be right beside it and when traffic starts, both will cross the intersection together. Therefore, to assist in aligning cars, traffic lanes should be indicated by white lines or some other means. If it is not possible to indicate these lanes throughout the entire length of the street, they should be marked far enough behind the pedestrian cross-walk to take care of the number of vehicles usually held by the stop signal.

One more thing may prove very helpful and that is a clear indication of the turning limits. If the center spots of the cross-walk lines, which continue the property lines, are embarked with a single or a traffic button, it will materially assist in correctly aligning both left turn and right turn vehicles and thus eliminate much confusion at intersections.

Each City Should Have Traffic Engineer.—If the National Safety Council is to fulfill the function which the general public expects it to fulfill, it must add to its already large staff of engineers, at least one competent traffic engineer for each state or regional district. It should be the duty of each such traffic engineer to study traffic conditions in the cities under his jurisdiction and be prepared to assist the local safety council and city authorities in the solution of the problem. Each city should in turn employ a competent traffic engineer of its own, who should have complete supervision of all phases of traffic within the city, consulting with the police department, the city electrical department, the safety council, the city planning commission, and the engineers of companies making traffic signals and control apparatus. Only by some such procedure as this can any city intelligently plan a signal system which will meet present conditions and permit extensions to take care of future demands.

It is quite a job to ask your organization to undertake, and yet there is no organization better qualified to undertake the task. You have the machinery—a national organization serving without profit and which is nationally respected. You have been useful and successful in so many other fields of endeavor, that I sincerely hope you will undertake this one. It will be a long, hard battle, for many cities have already installed signals, governing traffic with a multiplicity of conflicting laws—with reasonable exceptions, we must begin immediately to attain it. Only competent engineers will solve the problem. There are already too many amateur traffic experts who can only see one phase of the problem, and that none too clearly.

Cost of Snow Removal in California

The maintenance department of the California Highway Commission recently collected some information for the U. S. Bureau of Public Roads relative to the extent and cost of snow removal from California state highways during the 1926-27 season. The information is summarized as followed in California Highways:

A summary of reports from the several districts shows that 299 miles of state highways were cleared of snow. Of this total, 251 miles were kept open in Districts II and VIII and the remaining 48 miles were opened to travel by Districts III and IX forces earlier than if nature had been allowed to take her course. One 12-ft. rotary snow plow, eight straight-blade plows, 14 trucks, 14 tractors and 14 graders were available for the work. The cost of keeping the above mileage open was $15,970, and of opening the 48 miles was $6,180, a total expenditure of $22,-150 for the work. District VIII records indicate 7,600 mile-inches of snow removed at a cost of $1.58 per mile-inch.

Equipment Depreciation

Methods Tentatively Suggested by A. G. C. Committee

Recommendations concerning the standard methods of handling depreciation of contractors' equipment have been tentatively completed by the Special Committee on Depreciation appointed by the Associated General Contractors of America. The recommendations have been developed through cooperation with engineers of the Bureau of Internal Revenue. It is the intention of the bureau, after the joint studies are completed, to adopt the recommendations as standard practice for income tax returns.

The committee in charge of this work consists of Alan J. Parish, Chairman; R. A. Schaffner, of Siems, Helmers & Schaffner; Weston G. Hibbs, of the U. G. I. Contracting Co., and H. P. Converse, of the H. P. Converse Co. The detailed investigation is being conducted by John A. Grimes, engineer of the Internal Revenue Bureau, and Ward P. Christie, engineer of the Associated General Contractors.

The alternative methods tentatively suggested are set forth as follows in the September issue of The Constructor:

First, the old straight line method of depreciation which consists in estimating the useful life of each piece of equipment in years, and charging off a uniform portion of the initial cost during each year of the estimated useful life. That is, if a piece of equipment will last four years, one quarter of its cost or 25 per cent is charged to depreciation each year whether the equipment is in use or is idle.

Second, the unit of work method of depreciation, which consists in estimating the units of work which a piece of equipment will do before it becomes useless through wear or for other cause, then dividing the initial cost of the equipment by this number of units of work to find the cost of equipment consumed in doing one unit of work. These units may be tons, cubic yards, hours or any other suitable unit of measure. Thus, if a concrete mixer will do 20 miles of paving work before it is worn out, one-twentieth or 5 per cent of its initial cost is charged to depreciation for each mile of paving construction which it does. With this method depreciation is not charged on idle equipment but is charged on all equipment in use; that is, depreciation is charged for income producing equipment but not for non-income producing equipment.

Third, the job basis of depreciation which consists in charging the difference between first cost of a piece of equipment and its actual or estimated saleable value at the end of the job against the job for which the equipment was purchased. This method applies to special equipment purchased for a particular job, and for which no further use can be definitely predicted when the job for which it was purchased has been completed. The method also applies to contractors who make a practice of selling all equipment at the completion of each job and buying new equipment for the next contract.

Fourth, composite rate of depreciation determined by listing entire equipment with cost and item rates of depreciation (either straight line or unit of work item rates) and then determining an average rate for the entire equipment by dividing the total of the item amounts of depreciation by total cost of equipment. When a composite rate of depreciation is used there will be no charge to profit or loss when items of equipment become useless or obsolete, or otherwise are abandoned. The average rate is supposed to provide for all such contingencies and if one item does not last as long as estimated it is presumed that some other item will be useful for a longer time than was estimated and the loss on one will be balanced by over-depreciation of the other. The property account includes all items still in use at initial cost. When an item is disposed of, its initial cost is taken out of the property account and the initial cost less actual salvage value is also taken out of the depreciation reserve. That is, it is assumed that the depreciation reserve contains the full amount of actual depreciation on the item. As an illustration, say that there are two items of equal value each having an estimated life of five years, or twenty per cent depreciation on each is included in the average or composite rate. One item is scrapped at the end of four years and the other at the end of six years. No loss is written off for the four years item, but the composite rate of depreciation allows 20 per cent for six years or a depreciation of 120 per cent of the cost of the six-year item.

Fifth, the job basis can be used for special equipment and if this equipment is not sold but is retained by the contractor for use in possible future jobs, the balance of its cost may be depreciated either over the estimated remaining years of useful life or over the estimated remaining number of units of work of which the equipment is capable.

Before this standardization of methods can be completed successfully, it is necessary to obtain from the contracting industry more detailed information concerning the actual working life of the equipment as distinguished from the period of ownership. A number of companies with good records have volunteered to submit this to the committee but additional information is required. To obtain this it is likely that some sort of a questionnaire will be sent out by the committees.

The Operation of Sewage Treatment Plants

Manual Operations for Obtaining Maximum Efficiencies Described in Paper Presented April 22 at First Annual Meeting of Maryland Water and Sewage Plant Operators

By T. C. SCHAETZLE

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Sewage treatment plants are installations designed and constructed by man for the purpose of bringing about nature's changes as rapidly as possible, with a minimum of odor and other nuisances, and to prevent pollution of the water courses into which the treated sewages are discharged.

Operator's Duties.—To obtain these two objectives all sewage plants must be run on a strictly business basis. The operator may be likened to a factory manager, the treatment units to the office, machine shop, etc., while the bacterial, chemical and biochemical agents are the "workmen." No business manager would fail for a week, a day, or even an hour to assure himself that all details of the factory operation are receiving proper attention. In like manner, no sewage plant operator can afford to neglect his plant, no matter how small it may be. It must receive daily attention and the sooner those of us connected with this phase of sanitation realize that every sewage treatment unit needs definite daily attention, so that the unseen forces may produce the best results, the sooner will our operating difficulties be lessened.

Designing Engineer's Obligations.—The claim is often made that this or that plant would produce better results if properly operated. While it is true that many plants, not only in Maryland but everywhere, may not receive the best attention, yet operators have a just cause in their complaint that the engineer designs and builds the plant and then forgets it, never returning to learn how it is functioning. I believe that the designing engineers could materially help this situation if all of them would attempt to bind their client, be it municipality, industry or institution, to a contract retaining them for a few years to supervise the plant operation.

Furthermore, city authorities frequently have the opinion that when a sewage-treatment plant is installed, the problem is solved and the trouble ended. This is unfortunate as often the man selected as the operator is underpaid, receives little instruction in his duties, or, in the smaller communities, is assigned to one or more positions, so that the sewage plant work is done mechanically, if at all.

Likewise the average citizen does not know of the existence of a sewage plant or if he does, it is the last place on earth he cares to visit. Until the citizens and officials show more wholehearted interest in this necessary portion of municipal machinery, we shall continue to secure untrained and underpaid employees. As a result large investments are partly or wholly thrown away due to lack of proper operation.

Meaning of Good Operation.—Good sewage plant operation means the handling of the plant so that each unit performs its specific duty with the highest degree of efficiency. This can be accomplished only by constant and conscientious attention on the part of the operator. Let us consider, therefore, the nature of sewage, the usual processes of treatment, the purpose of each treatment unit and the means of obtaining or at least approaching the end desired.

In order to know the nature of the material to be handled, it might be best to stop for a moment to consider the composition of ordinary sewage. The sewage from a representative American city contains approximately the following constituents:

Solid matter, 200-800 parts per million	divided into	50% mineral of inoffensive material and 50% organic, that is, vegetable and animal matter which is offensive	25% of this is in suspension and 75% in solution whereas 40% of the offensive matter is in suspension and 60% in solution

The mineral matter such as clay and sand is of the least importance, except that it increases the bulk of solids to be handled.

The organic matter is of utmost importance, in fact, the whole sewage treatment operation is devised to arrange for its disposal in the least offensive and most economical manner. Organic matter always contains certain chemical elements (carbon, hydrogen and nitrogen) which change by the process known as decomposition. Decomposition is usually divided into two stages, putrefaction and oxidation.

Bacteria.—In the treatment of sewage these changes usually take place in the presence and through the action of very minute living organisms, so small that they cannot be seen with the naked eye. These organisms are known as bacteria. Roughly speaking, it would take from 5,000 to 20,000 bacteria, placed side by side to make a line 1 in. long. It is these organisms which use the organic matter contained in sewage as their food and in this way break down the complex compounds into simpler and less harmful products.

The air we breathe plays an important part in sewage treatment because it contains oxygen. Whenever oxygen combines with another substance we call the process "oxidation." This process occurs at sewage plants in the trickling filters, contact beds and sand beds. As a definite quantity of the organic matter in sewage requires sufficient oxygen to change it to a stable form, that is, a condition where there will be no further need for oxygen, the efficency of these devices is measured by the degree to which this matter has been oxidized. As oxygen dissolves in water, it is this dissolved oxygen that is used in the oxidation of sewage.

Putrefaction.—When oxygen is removed from a substance, we call the process reduction. When this process continues far enough to remove all the oxygen present in sewage and no more is supplied, the remaining undecomposed matter will putrefy, that is, develop disagreeable odors.

These two references to chemical reactions are given here only to provide a better understanding of what is to follow and to indicate that there are certain tests available to the chemist, which enables him to determine how his plant is working.

Usual Sewage Treatment Processes.—We are now ready to consider the usual processes of sewage treatment. The first step usually is to remove the very large particles by screens. Then it is passed through tanks to settle out as much as possible of the suspended solids. Where the sewage includes storm water, grit chambers are used to remove the heavier mineral matter. From the tanks, the sewage passes through some type of control apparatus to the filter or oxidizing beds. From here it is not common to resettle the sewage or to treat it with a disinfectant to kill the harmful bacteria. When the activated sludge process is used presedimentation may or may not be used but the oxidizing beds are omitted.

Screens.—Screening of sewage is accomplished by coarse and fine screens. The former are usually stationary, whereas the latter may be movable or fixed. The object of screening is to remove much floating and suspended matter as would tend to clog the pumping machinery, filter nozzles or any other portion of the sewage plant or to prevent the discharge of unsightly

material into the receiving body of water if fairly complete treatment is not given to the sewage.

Operation of Screens. — Screens should be inspected daily to see that they are doing the work expected of them. Fine screens are usually self-cleansing, but the coarse fixed screen must be cleaned by hand. It is well to do this each day, even though the deposit may be small. Care should be taken to prevent pushing some of the larger particles, such as rags, through the openings as this material may cause difficulties in other portions of the plant. If large quantities of material accumulate, the organic matter held back will soon start to decompose and produce objectionable odors.

The manner of disposing of screenings depends largely upon local conditions, primarily the size of the plant. Burning or burying is usually resorted to. When buried, at least 4 in. of earth cover should be provided.

Grit Chambers.—When sewage contains considerable sand, clay, or similar matter, a grit chamber should follow the screens. This is ordinarily the case when the storm water and household wastes enter the same sewer system. The only function of this structure is to reduce the rate of flow of the sewage to such a point that sand, gravel and other mineral substances will settle out and the lighter organic solids will remain in suspension (velocity about 1 foot per second).)

These chambers should be cleaned after every large storm and in dry weather when the deposited material is sufficient to increase the rate of flow through them to such an extent as to reduce their settling efficiency. If properly designed and operated the deposit should contain little organic matter. This means it is non-putrescible and inoffensive and can be used for fill, road building, etc.

Like all mechanical equipment, the valves and sluice gates of the grit chamber should be examined and oiled at regular intervals to insure ready operation.

Tanks.—Following preliminary treatment, the sewage is subjected to a settling process on one or more types of tanks. The most common forms are the plain settling, septic and Imhoff tanks.

Each of these tanks have one purpose in common, the removal of the solid particles carried in suspension. This is the only function of the plain settling tank. As some of the particles are heavier and some lighter than water, it is evident that by reducing the velocity of flow the lighter particles come to the top and the others sink to the bottom.

In operation these tanks require constant attention. The floating material should be skimmed off at least daily, either by hand or by some mechanical device. The skimmings are usually buried. The time for drawing sludge depends upon the individual tanks. This can be determined by physical and chemical tests, by sounding the sludge depth, or by watching the effluent. The suldge should not be allowed to accumulate so as to reduce materially the active settling portion of the tank and thus increasing the velocity and increasing the solids carried off in the effluent.

The sludge from these tanks should be placed in other tanks known as digestion tanks.

A septic tank is a continuous flow sedimentation tank, which, in addition to removing suspended matter, reduces the volume and weight of the deposited sludge by bacterial action.

When the accumulation of scum or deposited sludge becomes so large that the working area of the tank is materially decreased or the effluent carries an excessive amount of suspended matter, the scum must be removed and the digested part of the sludge placed on drying beds. Either one or both of these operations may be performed at the same time. If more than one septic tank is available, it is good practtice to allow the one from which sludge is to be withdrawn to remain idle for a few weeks to permit more complete digestion of the sludge.

Imhoff Tanks.—An Imhoff Tank is a structure which has two stories. In the top, the suspended solids are removed by settling, whereas in the bottom these solids undergo the process known as digestion.

Broadly speaking, digestion is a process by which the organic portion of the sludge is liquefied, gasified and mineralized.

Imhoff Tanks probably are used more extensively at small municipal and institutional installations than any other type of tank. Constant attention is essential. The inlet and outlet channels must be kept clean at all times. All material floating on the sedimentation chamber should be skimmed off daily or oftener, if necessary. The skimmer, as well as a number of other devices referred to in this paper, can be constructed along the lines illustrated in Catalog No. 31 of the Pacific Flush-Tank Co. The walls and sloping bottoms should be cleaned with a squeegee at least twice a week. Care should be taken not to stir the tank contents too much. In reversible tanks the flow should be reversed about every two weeks to insure even deposits of sludge. The slots at the bottom of the sedimentation chamber should be kept open.

The scum in the gas vents should be kept broken up by churning or by means of a water jet so as to allow the escape of gas. Sometimes this scum accumulates to such a depth that it cannot be kept in a semi-liquid condition and must be removed. Foaming occurs at times. The best remedy for this is not known to the writer. Various methods, such as spraying with water, drawing sludge frequently in small amounts, and the application of liquid chlorine have been tried with varying degrees of success.

Sludge should never be allowed to accumulate in the digestion chamber so that it is nearer than 2 ft. from the slot at the bottom of the sedimentation chamber. This can be determined by soundings at regular intervals, preferably at least once a month during the open season. The writer has found a weighted circular plate 12 in. in diameter, attached to a wire to be the best sounder. Others prefer sampling with bottles lowered to various depths. This is usually done by attaching the bottle to a pole, lowering it to the desired depth, pulling the stopper with a cord previously attached and finally withdrawing the bottle more or less filled with sludge.

Well ripened sludge should be drawn off into sludge drying beds at intervals varying with different plants. In this state once a month probably is a fair average time interval for the period from April 1 to December 1. Never remove all the well digested sludge. At times, when foaming occurs in the gas vents and gassing brings considerable sludge to the surface of the sedimentation chamber, sludge must be drawn regardless of its condition.

Well digested sludge is almost black in color and has a tarry odor. Undigested sludge is grayish in color, sticky, does not dry well and has an offensive odor.

At many plants it has been a difficult problem to obtain well digested sludge. Several years ago the speaker determined some ratios of the rate and degree of digestion to the amount of seeding material used. It was learned then that the degree of alkalinity or acidity of the sludge had a bearing upon the speed and degree of digestion. Within the past few years, it has been found that the application of lime to sludge and scum to obtain a pH value between 7.3 and 7.6 will produce the best and most rapid digestion of sludge.

The pT scale can be likened to the thermometer scale. On this scale 32° represents the freezing point of water. Any values higher than 32° denotes an increase in heat whereas any values be-32° denote an increase in coldness| In other words, the degree of heat increases as the numbers increase and the degree of coldness increases as the numbers decrease. In like manner the degree of alkalinity or acidity of a solution is xpressed by the Hydrogen Ion Scale where we use pH values instead of degrees. At pH 7.0 we have a neutral solution. With a decrease in these figures the acidity of the substance being tested increases whereas with an increase in numbers we have an increase in alkalinity. In other words, if we have a pH of 6.8 we need lime to obtain a pH of 7.3 to 7.6, but not as much as would be needed if the pH were 6.0. The best method or place of applying the lime in actual practice is open for discussion.

Digestion tanks are separate tanks into which plain sedimentation tank or undigested sludge is placed for digestion. The temperature of the sludge in separate digestion tanks or in the sludge chamber of Imhoff Tanks, has a material bearing upon the digestion process taking place therein. A uniform temperature of about 70°F. is beneficial.

Dosing or Control Devices.—Dosing devices are used to control the application of settled sewage to the oxidizing units. At large plants various controls may be employed but at small plants the automatic sewage siphon usually is used. Only liquid should enter the dosing chamber. This should be drained occasionally and the sides and bottom cleaned as an excessive accumulation of solids may interfere with the operation of the siphon.

The failure of sewage siphons to operate properly is usually due to one of two causes, namely, an air leak in the bell or some part of the piping connected to the bell, or the clogging of the apparatus.

Oxidizing Device.—The usual oxidizing devices at sewages plants are trickling filters, contact beds and sand filters. The primary object of these units is to add sufficient oxygen to the settled sewage to make it stable, that is, to prevent odor production and to reduce the oxygen demand of this liquid. By accomplishing the latter the production of a nuisance in the body of water into which the sewage plant effluent will discharge may be avoided.

The operation of each of these types of oxidizing devices is somewhat different, but, to accomplish their ultimate object, certain attention is required. It is possible, of course, to determine their efficiency by chemical tests, to be illustrated this afternoon, but my only purpose here is to indicate the regular attention these units require.

Trickling Filter. — Although automatic in action the trickling filter needs regular attention. To obtain maximum efficiency of these beds the sewage should be distributed evenly. This means that the nozzles and rinser pipes must be kept clean and free from deposits and growths.

Occasionally pooling occurs on these beds. This unually is due to a greenish growth common to these filters. Pooling should be prevented by keeping the surface of the beds clear of grass, weeds and this green growth. The latter can be removed by flushing with a hose, turning the surface over with forks or rakes, or where possible, by allowing the bed to remain idle for from 24 to 48 hours and then turning on the sewage. By the latter method the dried film washes away easily, but this procedure may produce objectionable odors. It is claimed that the application of copper sulphate or liquid chlorine wil' remedy this condition.

During the winter it becomes necessary at some plants to remove the nozzles entirely to avoid freezing. Although this procedure must be followed the nozzles shoulde be replaced as early in the spring as weather conditions will permit.

A disagreeable feature of trickling filters is the breeding of a small moth fly in the top few inches of the stone bed. This can be controlled by flooding the bed. Recently it has been claimed that the breeding of these flies can be controlled also by applying liquid chlorine every fourteen days to the sewage being sprayed on the bed.

Contact Beds.—The number of contact beds in active use in Maryland is small. It may be well, therefore, to state that, while trickling filters and contact beds are built of stone, the real difference in them lies in the method of operation. With trickling filters the sewage is applied continuously and evenly, whereas for contact beds the sewage is applied, then allowed to remain in the bed for some time and then after emptying, the bed is allowed to remain idle. A representative cycle for contact beds is: one hour filling, two hours standing full, fifteen minutes emptying and approximately four hours resting. The most important feature of operation is to see that the best cycle is determined and then maintained and that the beds are given a complete rest of two days every six or eight weeks.

Sand Filters.—In the operation of sand beds sewage is applied intermittently to the surface of the bed, sufficient time being allowed between doses to let the bed return to its best operating condition by reason of the oxygen drawn into the bed as the sewage seeps through.

In caring for these beds it is always necessary to see that the beds are not dosed too frequently. After once determining the best period between doses, probably not less than 6 hours, this rate should be maintained. When a mat forms on the bed so that the sewage cannot pass through freely this should be removed. Although it sometimes becomes necessary to loosen up several inches of the sand to get good operation the sand should never be turned over without first cleaning off all deposits. Always keep the beds as level as possible and apply the sewage uniformly, giving careful attention to the distributor system. No growth of grass or weeds should be allowed on the beds and heavy wagons should be kept off of them. Repair all wash-ins and broken ventilators at once. Never allow the application of sewage in such a way that it will find its way through holes directly to the underdrains.

Winter operation of sand beds is important. In the late fall the beds should be placed in first class condition. The sand should be ridged and furrowed or placed in piles so that when the first dose of sewage is applied to the bed, the surface of the liquid will freeze and the rest of the liquid will pass through the sand, the sheet of ice being supported by the ridges or piles. Advantage should be taken of the warm days to remove the sludge mat, if necessary. Early in the spring the surface of the sand should be cleaned, the sand loosened and the beds leveled.

Activated Sludge Treatment.—There is a system of oxidizing sewage without applying it to contact beds, trickling filters or sand filters. This process is known as "Activated Sludge" treatment. Sludge in a brown, flocculent condition is thoroughly mixed with the raw sewage by means of compressed air. By this thorough mixing and addition of air the solids in the raw sewage are so changed that they will settle in a second tank and the tank effluent will approach stability.

Much could be said about this method of sewage treatment, but it is enough to state here that this type of plant requires very careful attention. Among the items to be looked after are the mixture of a proper amount of activated sludge with the raw sewage, the adjustment of the proper amount of air added, the cleaning of the settling tanks when needed and numerous problems involved in the handling and disposal of sludge.

Disinfection.—It frequently happens that it is necessary to disinfect a sewage plant effluent to protect a watercourse which may be used later as a water supply, by cattle or for shellfish growing. Perhaps the most effective and economical method of disinfection, or at any rate the one most in use, is the application of liquid chlorine. A number of details must be cared for on liquid chlorine machines. It is well to mention, however, that a method of determining whether or not sufficient chlorine is being added should be used by all operators. This is a simple test for what is called "residual chlorine." This test was demonstrated yesterday afternoon. Remember to apply an ample amount of chlorine, however, so that the residual chlorine is equal to at least 0.5 p.p.m. after ten minutes contact.

Sludge Treatment and Disposal.—The disposal of the solids removed from sewage by settling, commonly known as sludge, presents a very difficult problem. In the fresh condition it is very offensive. It is usually changed from this condition to an inoffensive or digested condition in the sludge compartment of an Imhoff tank or in separate sludge digestion tanks. After digestion it is ordinarily applied to sand beds for drying, but, at some of the larger plants, filter presses and centrifuges have been used.

For sand bed drying the most efficient operation is obtained by applying the sludge to the beds to a depth not greater than 12 in., but preferably not more than 8 in. The sludge should be thoroughly dried and removed before applying more sludge to the sand bed. Never dig holes through the bed to make the sludge drain more freely as

this leads to dirty sand and not infrequently to clogged underdrains. The addition of aluminum sulphate and to the sludge as it is placed on the bed hastens drying. Do not send undigested sludge to the drying beds if this can be avoided. Prevent contact between sludge and sand or earth embankments at the edge of the sludge layer as flies breed in earth or sand saturated with sludge liquor.

Miscellaneous.—It is well to have water supplied under suitable pressure at every plant. This helps in breaking up the scum in the gas vents of Imhoff tanks, the removal of the growth on the trickling filters and in keeping the plant generally tidy.

Sewage should never be by-passed around any unit of the plant, except in extreme emergency. If done a complete record of the time and reason for by-passing should be kept.

It is of utmost importance to keep conditions around any factory attractive and clean. In like manner the operator should do his best to make his plant attractive by cleanliness, planting of flowers and shrubbery, keeping the lawn cut and the pathways straight and clear of debris. If this is done the average citizen will be more likely to visit the plant and show increasing interest in the more or less unattractive position of the operator.

Operation Records.—A record of the plant operation should always be kept. The Engineering Bureau of the State Department of Health will gladly assist any operator in drawing up a record form for his plant. Such records will give him more intimate knowledge of what the plant is doing. When no laboratory facilities are provided, considerable knowledge of the manner in which the small plant is operating can be obtained by the use of Imhoff cones for estimating the settling efficiency of the tanks, and by the methylene blue test for the determination of the stability of a trickling filter, contact bed or sand bed effluent.

Summary.—To summarize briefly, it has been pointed out that:

1. Sewage treatment plants are constructed for the purpose of changing the organic content of sewage to an inoffensive condition as rapidly as possible, with a minimum of odor and other nuisances, and to prevent pollution of the watercourses into which the treated sewages are discharged.
2. The citizen, official, designing engineer and operator all have a joint responsibility in bringing about successful operation of a sewage treatment plant. The citizen must show more interest, the official must pay better salaries for the more or less disagreeable duties performed by the operator, the designing engineer must not design and forget, but rather keep in touch with the operator to act in an advisory capacity and the operator must be thoroughly and intelligently interested in his work.
3. The operator must realize that he is in charge of an important factory whose processes he must understand. It may produce nothing marketable, but only by proper management will the sewage plant produce a satisfactory effluent and eliminate or reduce the odors at the plant to a minimum.
4. The plant should receive careful, daily attention.
5. No plant is automatic and it will not operate, therefore, without regular attention. Definite operations, for example, as squeegeeing the sloping walls of the Imhoff tanks, must be performed at definite intervals. Until such regular attention is given to the sewage plant operating difficulties will not be reduced to a minimum.
6. Daily records are essential for best operation.
7. Where no laboratory is available the Imhoff cone test is recommended for a test of the settling efficiency of the tanks and the methylene blue test for the effect of the oxidizing device upon the treated sewage.
8. Where sludge is adjusted by the use of lime to obtain better digestion, the colorimetric pH test is valuable.
9. Whenever disinfection by the use of liquid chlorine is used the test for residual chlorine is essential.
10. The Engineering Bureau of the State Department of Health is at the service of the public to render such assistance in preparing record forms, instructing the operators in the details of the simple tests referred to or in any other phase of plant operation in which the town official or plant operator may feel that it can be of assistance.

Conclusion.—In conclusion, I should like to emphasize the fact that sewage treatment still presents many difficulties and that the remedy for a specific difficulty at one plant may not be a solution for what seems to be a similar difficulty at another plant. The solution of these problems may be largely facilitated by exchanging ideas, so that each of us may benefit by the experience of the others.

Slag-Clay and Sand Asphalt in Delaware

Two new types of paving were tried in Delaware during 1926—sand asphalt and slag-clay road. About six miles of the former was constructed to take advantage of local sand. This type is cheaper than concrete, and can take traffic within one day of laying. Slag-clay was used on secondary roads, a total of 19.4 miles being completed.

Rubbish Salvage at Baltimore Incinerator

Material salvaged at the incinerator of Baltimore, Md., practically pays for the operation of the plant, according to the Baltimore Municipal Journal. The householder is required to keep refuse in three separate containers—one for garbage, one for ashes, and one for rubbish. The containers for garbage and ashes must be of metal and have covers. Their capacity must not exceed 10 gal. Any kind of receptacle may be used for rubbish, but it must be limited to two bushels in capacity. It is necessary to have three containers because the ashes are still hauled to the dump and the garbage to the reduction works. Warning also is given that garbage should not be wrapped in paper, as this causes much trouble and expense. It also is important that the rubbish be kept dry, because if it is not it is both troublesome and expensive to handle at the incinerator.

The trailers or trucks hauling the rubbish upon arrival at the plant make their first stop on the scales. Here every load is weighed, as the contractor is paid a certain amount per ton for collecting and hauling the rubbish. Each load then is dumped into a large hole in the dumping floor. This opens into a bin holding 175 tons of rubbish. At the bottom of this bin is a large steel belt upon which men place the rubbish. All the material dumped is then conveyed up an incline to the next floor. The salvage work begins at this point. A force of workers is engaged in removing all material that can be sold. This includes all the good dry paper, rags, bottles, tin cans, rope, shoes, brass, iron, copper, aluminum, and other metals. The worthless material continues on the belt and is dumped into a furnace where it is burned on a moving chain grate. At the end of this grate the ashes fall on another belt and are conveyed out of the plant and to the dump.

All the paper that has been salvaged is placed in bales of about 1,000 lb. each. Bales also are made of the rags, old carpets, window curtains, cordage, etc., and this material as well as the paper is sold for reclamation.

The tin cans are fed from a large bin into a press which squeezes them into blocks about 14 in. square, weighing about 35 lb. These are sold for use in making window weights. All the bottles are separated according to size and sold. The broken glass goes back to the glass works and is remelted.

The milk bottles found in the rubbish and which are unbroken are returned to the dairies to which they belong.

Metals of all kinds salvaged from the rubbish are sold to various plants where they are made into useful articles.

Garbage collected from the homes is hauled to the harbor where it is loaded on scows and taken 21 miles down the river to the garbage reduction plant.

Ornamental Concrete in Houston Parks

How Craftsmen Imitated Trees and Rocks in Permanent Material for Park Zoo Purposes Told in Concrete Highways and Public Improvements

By CLARENCE L. BROCK
Superintendent Public Parks Department, Houston, Texas

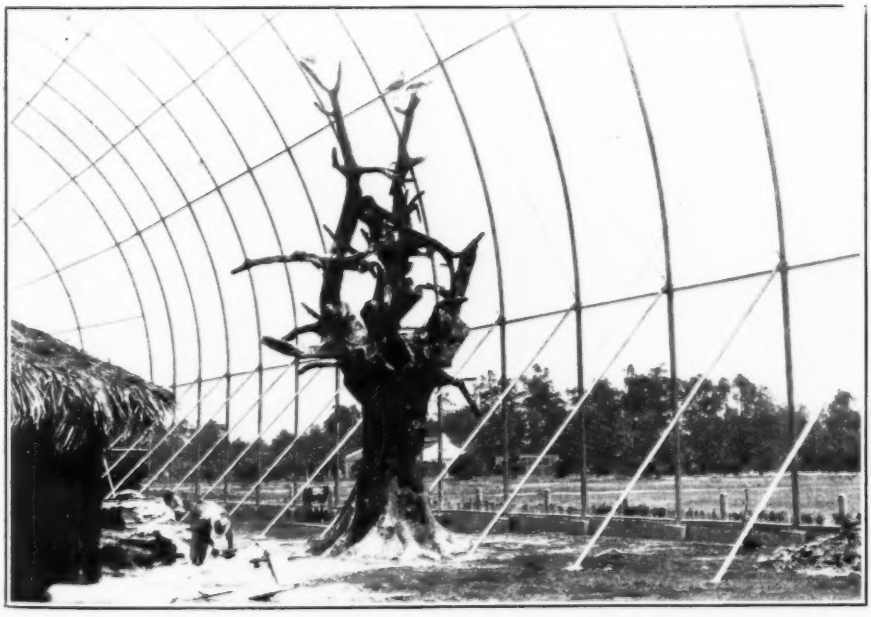
Houston has nearly 3,000 acres in its 29 public parks. Many of the smaller parks have been made into completely equipped neighborhood playgrounds but of the larger areas only Hermann Park has been extensively developed. There, in the construction of dens and cages for the zoo, we are using concrete to imitate trees and stones and are getting results so remarkable that it is almost impossible for anyone who does not have a chance to touch or strike the concrete to distinguish it from wood. While this work is barely started, it overshadows, for accurate mimicry and true artistry, anything of the sort it has ever been our good fortune to see.

Dionecio Rodriguez, from Mexico City, is the artist. It is impossible to convey with words an adequate idea of the perfection of his work. And because ordinary pictures do not reproduce color, they too fail to tell the story adequately. For it is the coloring which makes his work truly remarkable. There is the gray-brown of weathered wood where the bark has been stripped away, the grayish-green of lichens on rocks or decaying roots, the darker varicolored tints of the bark.

So far this work has been confined to three trees and a waterfall in which concrete imitates coral rock. Two of the trees are standing, one lies at the foot of the fall, its butt still resting on the stump, as though it had been beaten down by some great storm. The standing trees are oaks; the one at the foot of the falls is, appropriately, that lover of rocky ledges, a cedar.

Another of the Grotesque But True-of-Life Trees Built of Concrete. This Tree Is an Oak

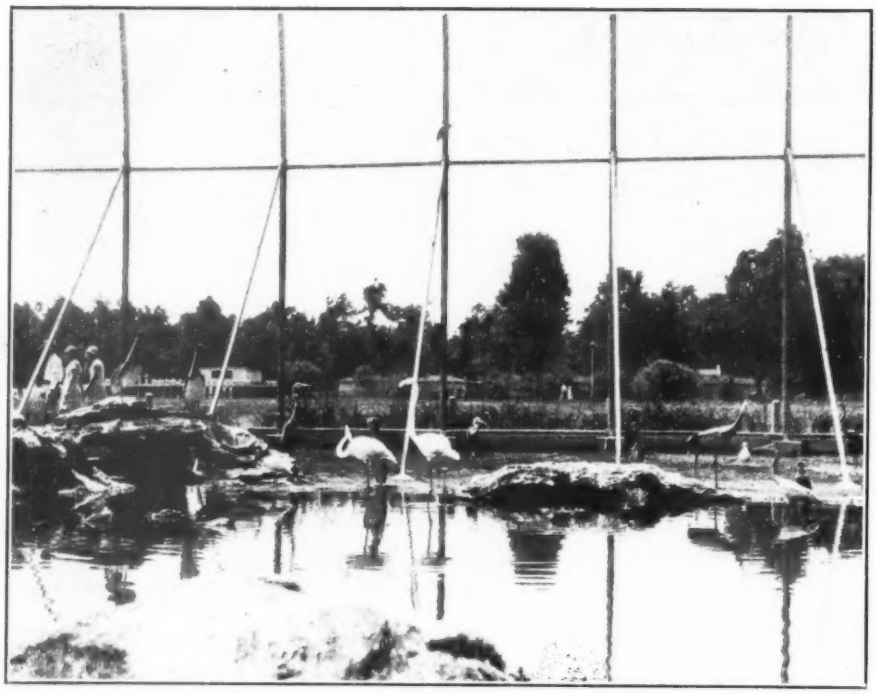
All these are inside the flight cage, where the larger birds are confined. From outside the cage no one would dream that the trees are artificial, yet it is upon short-range inspection that the work seems most remarkable. For it is then that the life-like weather checks, the worm holes, the smooth-edged bark bordering some old wound and the little splinters bridging the wider cracks show in their true perfection.



An Interior View of the Flight Cage Showing One of the Concrete Trees and a Concrete Rock Ledge

"How does he do it?" is the inevitable question of those who are told that the trees are really concrete. "What form does he use to cast a thing like that?" He uses no forms at all. He fashions every piece of bark, drills every worm hole, makes every weather check and crack by hand, before the surface concrete has hardened. And when it is finished he colors it. That is the only part of the process which he keeps secret. He uses ordinary mineral colors, hydrochloric and sulphuric acid, but he alone knows how he mixes them.

The trees and the waterfall are hollow. In making them a substantial concrete foundation was first built. Upon this foundation a framework of steel rods and wire mesh was set up. The mesh wires are spaced 2 in. apart each way. It was hung on the rods so that it roughly outlined the inner and outer surfaces of the rock or tree. Then the



Artificial Rocks Along the Edge of the Pool. The Concrete Is Colored and Molded to Imitate Coral Rock

space between the two layers of mesh was filled with concrete, which was allowed to harden. The surface was put on like stucco, a little at a time, starting from the top so that the finished portion would not be marred by dropping mortar. Knots and ridges were made over pieces of brick pushed into the fresh mortar and skillfully covered. It took Rodriguez and two helpers a month to make the larger tree shown in the picture.

At first only home-made tools were used. A bundle of straws, twigs or pine needles tied together formed a brush with which the surface was given a grained appearance; baled hay wires, cut to the same length, were wrapped into a bundle and the ends spread apart to form a tool for making worm holes. Recently we bought a set of ornamental cement finisher's tools which have proved useful, but home-made tools are still needed to fit special cases.

When the tree or rock is all fashioned Rodriguez puts up a little canvas sheler behind which he works when he applies the colors. The whole thing is first painted a dull color; in the case of trees it is the color of weathered wood. Some neat cement is mixed with the colors to make them stick. Then the variations from this color are added. And finally the whole thing is washed with acid—either muriatic or sulphuric, and perhaps both. This acid wash seems to make the concrete have texture and gives the color the appearance of coming from inside the surface. It is that characteristic of the coloring which makes the imitations seem so real, for it does not look at all like ordinary paint.

We expect to continue this same type of work on our new sea lion pool, eagle cage, parrot cage, bear dens and monkey island, which will be built this year.

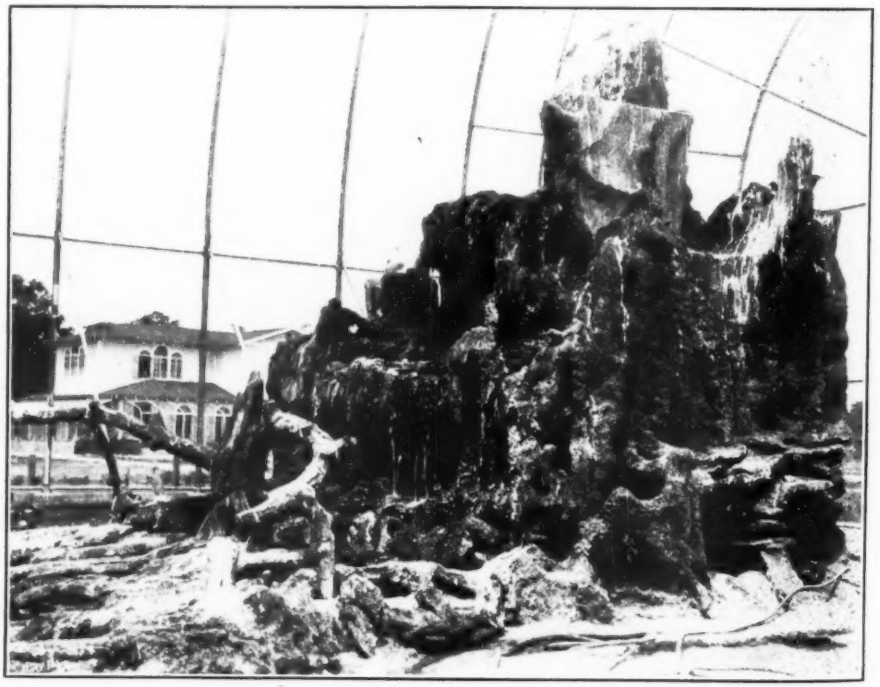
We are, of course, using concrete in many other ways. We recently completed a house for primates which is largely concrete and have built some concrete walks and steps which add materially to the beauty of the grounds, especially in the sunken gardens. Concrete tennis courts have also proved popular, especially in wet weather.

The new dens will be the sort that make the animals seem free; there will be no bars or wire netting, just concrete, fashioned into inaccessible walls which look like the rocks in which animals so often have their dens.

Concrete Deck for Steel Barge

An experimental concrete deck was constructed recently on a steel barge by the general repair station of the Louisville District of the U. S. Engineers Department, as an attempt to obtain a suitable reinforcement for the decks of steel barges. This barge was 110 ft. long by 27 ft. wide, the area within the cargo box being 9 ft. by 23 ft. 30 lb. rails were placed on 23 in. center, fore and after of the barge, and tied down to the deck beams with clip plates 1¾x⅜x3 in., by means of ⅝ in. bolts 1½ to 2 in. in length. The concrete was of a minimum depth of 3⅛ in., increasing to an average of 3¾ in., due to the depressions in the deck plate between the beams. The mix used was 1:1.5:2.5, requiring 8 bags of cement, 12 cu. ft. of sand and 20 cu. ft. of gravel per yard of concrete, with a consistency equivalent to a 4-in. slump. In all 25¼ cu. yds. of concrete and 5¼ tons of rail was required. The draft of the barge was increased 7 in.

Blasting Machine Equipped With Lock.—The Oliver Iron Mining Co., of Minnesota, uses blasting machines equipped with locks. The rack bars of the blasting machines have been slotted and locks installed so that the handle cannot be raised until the bar is unlocked. The shot-firer is the only one provided with a key.



The Waterfall and Fallen Cedar Group. Some Idea of the Huge Amount of Work Required to Mold and Color the Concrete Is Indicated in This View

Meter Reading and Billing

Practice at Milwaukee, Wis., Described in June Journal American Water Works Association

By H. P. BOHMANN
Superintendent of Water Works, Milwaukee, Wis.

Meter reading is the foundation of the revenue of a water works and in order that the amount of water consumed may be intelligently computed it is essential that this work be accurately, honestly and frequently performed. At Milwaukee with 78,200 meters in service Jan. 1, 1926, meters of small consumers are read monthly, meters of large consumers bi-weekly and contractors' meters weekly.

While the duties of a meter reader are primarily the recording of the registration of the meters, he has other functions or duties that are scarcely less important to the department.

Testing for Accurate Registration.—These include testing of the meter to ascertain if it is properly registering. Only by frequent readings can the department have a check on the performance of the meters and by a proper method of reporting all meter defects and the immediate remedying of those defects by an efficient repair department can the department be in a position to render bills that are just and equitable.

Where many meters are in service many accounts must be "averaged" each year on account of meters being temporarily out of order. The period during which a meter is not operating properly is greatly reduced by frequent readings of the meter, with a result that with monthly readings the average length of time a meter would be out of order before being discovered would be but 15 days. Bills when rendered therefore reflect to a greater extent the actual consumption than if a meter is out of order the greater part or all of the period covered by the bill.

Frequently when consumers receive "averaged bills" complaint is made in regard to the quantity of water consumed. When the consumer can be shown that only a small fractional part of the period is "averaged" and the balance actual registration with the short averaged portion on the basis of the actual registration, it is usually an easy matter to convince him as to the equity of the charge. This applies especially to large consumers where the amount involved is considerable.

All meters of large consumers in Milwaukee are read bi-weekly thereby still further reducing the average length of time the meter is out of order and lessening the time covered by the average when computing bills. Meters set for construction purposes are read weekly, which gives us an excellent check on the consumption on account of the great variations during different periods as the construction progresses. It prevents in a great measure tampering with the meter, either intentionally or otherwise.

Detection of Unusual Consumption.—Secondly, investigation of the cause of unusual consumption and notification of the consumer are assured.

While the water meter furnishes the most accurate basis for charging for water, it serves another important purpose, namely, that of a safeguard and protection to the consumer as well as to the water works in case of leakage, etc. It measures accurately the consumption and all extraordinary conditions existing are early reflected by the registration of the meter. Again frequency of readings has the advantage of bringing discovery with the least delay and affording an opportunity to the consumer to avoid excessive water bills.

At Milwaukee, whenever an unusually large registration is shown by meter, a notice is left with the owner, if he resides on the premises or mailed to him if he does not, calling his attention to the extraordinary condition and asking him to investigate without delay to avoid a large bill. On account of reading meters monthly and large meters bi-weekly a great saving is shown, as the average length such condition exists will not exceed 15 days for small consumers and 7 days for large consumers. This is especially valuable where underground leaks exist that find their way into a drain or sewer and do not show on the surface.

For example, take a small consumer in moderate or poor circumstances whose water bill amounts to only a few dollars annually. Suppose an underground leak existed that did not make itself apparent on the surface or in any other way. If the meter is read frequently the very next time the reader called after such a condition developed he could not help discovering it. By notifying the owner at once, steps could be taken immediately to have the necessary repairs made with but small loss. On the other hand, if this condition had been allowed to exist for three or more months before discovered, a tremendous bill would have accured, with a hardship on the consumer with benefit to no one. While it would temporarily increase the revenue of the department, it would leave a bitter feeling in the mind of the consumer toward the department. Even a very small leak running 24 hours a day will in three months' time amount to considerable.

At Milwaukee approximately 26,000 "large consumption" notices were delivered to consumers or owners during the year 1925, which has resulted in a great saving to consumers.

We have on file many letters of thanks from consumers for calling their attention to high water consumption. Consumers realize that the efforts of the department are to furnish the best possible service and to help them avoid unnecessarily high water bills.

Most complaints received are in regard to large consumption. With our frequent or continuous readings and close attention to conditions by meter readers, we are able to adjust satisfactorily all complaints and avoid controversies with consumers.

Detection of Violation of Rules.—Thirdly, policing of districts in regard to violation of the rules and regulations of the department is possible through frequent meter readings.

Meter readers are obliged to familiarize themselves thoroughly with every condition in their respetcive districts. While primarily engaged in reading meters and safeguarding the interests of the consumer, the meter reader also safeguards the interests of the department as well as that of the city in general. He must see that contractors have proper permits when using unmetered water, report all illegal opening of fire hydrants, leaks or breaks in mains, etc., or any other violation of the rules and regulations of the department. They co-operate also with other divisions and departments of the city service in regard to sanitary and health conditions in their district.

Water meters frequently run over, i. e., reach their full dial capacity and repeat one or more times each quarter. Where meters are read only periodically, it is practically impossible to compute accurately the amount of water consumed, as it is not evidenced by the meter that such had been the case and considerable revenue may be lost to the water works in this manner.

By reading meters continuously the department is in a position to employ meter readers permanently, insuring accuracy and efficiency in the performance of their duties.

Frequent readings of meters protect the water works, insofar that they eliminate almost entirely the tampering with water supply or meters. Taking readings infrequently or at long intervals affords an opportunity for all kinds of liberties with the water supply or meters by unscrupulous consumers and many times unintentionally by honest consumers, with a result that the department may lose many times the cost of additional inspection. If

water supply or meters are tampered with, it leads to almost immediate discovery before the consequences are considerable.

It is generally conceded that where meters are not read frequently, when leakage occurs some abatement or adjustment of the amount of bill should be made and usually on a 50 per cent basis. It is claimed that approximately 3 per cent of the total assessment for water rates is so rebated where that pratcice is followed. Assuming this figure on an annual assessment such as the city of Milwaukee, the amount of loss to the water works due to such adjustments would approximately amount to the entire annual expense for reading meters on a monthly basis. As a matter of fact the abatements made by the city of Milwaukee due to leakage do not average $50.00 annually.

A water works, especially if municipally operated, should not endeavor to make money, but rather to give the maximum of service at the lowest rate to the greatest numbers of consumers.

That Milwaukee is not the only city that believes in continuous meter reading is evidenced by an extract from The Journal A. W. W. A., Vol. 1, No. 2, June, 1914. The report of the Committee on Tabulation of Water Rates, etc., shows that, of a total of 257 cities, 177 or 69 per cent read meters monthly, while only 69 or 27 per cent read meters quarterly.

General Practice in Frequency of Meter Reading.—The above report being too ancient to reflect present day practice, questionnaires were sent to 37 cities having a population of 100,000 and over. Thirty-two replies were received, representing a total population of 11,617,000 with 1,701,200 meters in service, an average of 86 per cent of water consumers metered. Abstracts from the above revealed the following:

Frequency of Meter Readings

Small consumers:	
Semi-annually	1
Four-monthly	2
Quarterly	16
Bi-monthly	3
Monthly	10
Total	32

10 or 31 per cent favor monthly reading
3 or 9 per cent favor bi-monthly reading
16 or 50 per cent favor quarterly reading
3 or 9 per cent favor less frequent reading

Large consumers:	
Quarterly	7
Monthly	23
Bi-weekly	2
Total	32

7 or 22 per cent favor quarterly reading
23 or 72 per cent favor monthly reading
2 or 6 per cent favor frequent reading

Do You Favor Monthly Readings?

15 or 47 per cent favor monthly readings
13 or 41 per cent favor monthly readings large consumers only
4 or 12 per cent favor less frequent readings

All replies received show that consumers are notified in case of leaks, large consumptions, etc. This is consistent practice as far as large consumers are concerned, for 25 or 80 per cent read large meters monthly or oftener. How this works out with the smaller consumer is hard to determine, as only 10 or 31 per cent read small meters monthly.

It would, appear therefore, that the small consumer, to whom perhaps the large bill is a greater hardship than to the large consumer, is not getting the same protection through the notification of large consumptions, leaks, etc., notwithstanding the fact that the small consumers represent a great majority of water takers. It is a well-known fact that, where leakage exists, it becomes greater the longer it exists.

On the other hand, where meters stop registering or become out of order, or read but periodically or infrequently, difficult is encountered in regard to computing properly the consumption due to seasonal or other conditions. Again the small consumer is not getting the proper protection and unfair and unjust assessments to the department as well as to the consumer may result.

Abstracts from the replies received prove conclusively that it is to the best interests of all concerned to read the large meters, or the small minority, frequently. Why should it not then also be to the best interests of all to read the small meters or the great majority just as frequently?

Eighty-eight per cent of the cities reporting are in favor of reading large meters monthly, while 47 per cent also favor monthly readings for small meters, with only 12 per cent in favor of less frequent readings.

If meters are read only as frequently as bills are rendered, it does not tend to the best service. Usually readings are taken during the final month before the billing period as rapidly as possible in order to get out the bills. Therefore, readings taken during the interim period afford readers better opportunity for observing conditions, testing meters, etc. It should be the ambition of a meter reader to get his route in such shape during the interim so that when taking the final readings for billing he will have as little trouble as possible. Where bills are rendered infrequently, I believe it to be false economy to use that as a guide or proper period for reading meters. No direct relation exists between the reading of the meter and the rendering of the bill.

Advantages of Continuous Over Periodic Readings.—The following is a résumé of the advantages of continuous over periodic readings of water meters.

1. Meter defects discovered shortly after occurrence.

2. Reducing period "averaged" when computing accounts, so that bills when rendered reflect as nearly as possible actual consumption.

3. Large consumptions, leaks, etc., discovered shortly after occurrence, affording consumer an opportunity to have repairs made and avoid excessive bills.

4. Minimizes difficulty in adjusting complaints about excessive bills.

5. Prevents violations of rules and regulations, illegal use of water by contractors, etc., co-operation with other departments.

6. Permanent employment for field force, thereby increasing efficiency.

7. Prevents tampering with water supply or meters.

8. Makes abatement or adjustment of large bills due to leaks unnecessary.

Continuous Versus Periodic Rendering of Bills.—Since the establishment of the Milwaukee Water Works metered water rates at this city have been collected quarterly. On January 1, 1926, 78,200 bills were issued and, with the additional accounts to be added during the year, approximately 320,000 bills will be issued and collected during the current year.

There has been no demand from a single individual for a change from the present system which has stood the test for fifty odd years under many administrations. It must have, therefore, some real merit.

Various plans have been investigated from time to time without finding a better one and all of them are more costly.

An abstract from the replies from 32 cities, as to the frequency of rendering bills, is shown below:

Frequency of Rendering Bills

Small consumers:	
Annually	2
Semi-annually	5
Quarterly	18
Bi-monthly	1
Monthly	6
Total	32

6 or 19 per cent favor monthly billing
1 or 3 per cent favor bi-monthly billing
18 or 56 per cent favor quarterly billing
7 or 22 per cent favor less frequent billing

Large consumers:	
Semi-annually	2
Quarterly	11
Monthly	19
Total	32

19 or 60 per cent favor monthly billing
11 or 34 per cent favor quarterly billing
2 or 6 per cent favor less frequent billing

In 56 per cent of the cities reporting quarterly billing is favored for small consumers, while 60 per cent favor monthly billing for large consumers. Seventy-nine per cent of the cities favor monthly billing for both small and large consumers, while 90 per cent favor quarterly billing.

Opinions differ greatly as to how often bills should be rendered, varying all the way from monthly to annually, but differ only slightly from the actual practice as reported below.

Small consumers:	
Annually	2
Semi-annually	4
Quarterly	16
Bi-monthly	1
Monthly	9
Total	32

9 or 28 per cent favor monthly billing
16 or 50 per cent favor quarterly billing

The Examination of Sinking Funds

Outline of Logical Procedure for Municipal Financial Officers to Follow in the Evaluation of Sinking Funds Given in Kansas Municipalities

By DONALD C. STONE

Cincinnati Bureau of Municipal Research, Cincinnati, Ohio

The character of sinking-fund administration has shown considerable improvement during recent years, thus conforming with the general trend towards economy and efficiency in public administration. Undoubtedly the number of cities in which corrupt practices have occurred in the control of sinking funds during the past decade is quite small. On the other hand, the cities which can be arraigned for inefficient and haphazard management are many.

This step from fraudulency to what might be called "honest inefficiency" is readily observed in the evolution of municipal government in this country. The public will no longer tolerate the scandalous misappropriations and graft which tainted the municipal administration of the previous century. The initial phase of this reaction to corruption did not initiate effective government. Its attainment was inhibited by the failure, first, to secure competent and able men in public office, and second, by the lack of effective methods and technique. The second phase of this reaction has been quite pronounced during the past ten years. It is exemplified by the adoption of the council-manager form of government by scores of cities and by the general movement toward competency and economy in municipal administration.

Sinking Fund Administration.—Concurrent with this evolution, the number of cities which correctly administer their sinking funds has greatly increased. Yet there are hundreds of municipalities, particularly the smaller ones, which do not enjoy competent sinking-funds administration. The installments which are placed in sinking funds are still frequently determined by approximation; many factors which affect vitally the size and frequency of these installments are not considered. In many instances the authorities do not know if their sinking-fund provisions are too small of too large. Although actuarial science has long been found indispensible for similar operations in the business world, it has been too frequently neglected in public administration. This may be due in part to the ignorance of public administrators. On the other hand, very little effort has been made to present to these administrators the necessary information in a practical manner. Most of the available material relating to this subject has been academic and theoretical.

When a public official is confronted by an entangled debt situation, his first questions will be: "Is there as much in the sinking fund as there should be?" and "Is the city going to come out all right when the day of reckoning comes?" Often there is no city employee who can accurately furnish this information. The procedure outlined later is designed to make the securing of this information a simple matter. It is prepared in such a manner that a knowledge of accounting and actuarial technique is unnecessary. In this manner, any public official can investigate the condition of the sinking funds and insure that they are properly administered. With the use of this guide a complete analysis of any term bond is enabled which will insure that future installments of the sinking fund will be actuarially correct. By means of this guide an intelligent examination of sinking funds may be made which will not only ascertain the existing conditon but also wll enable a remery of any inaccuracies or unsound conditions.

Contrary to the opinion of many sinking-fund administrators, the sinking-fund requirements do not always demand an annual recalculation. The task of recalculating the hundreds of bond series which exist in some of our larger cities would be an onerous duty. Yet, a cautious eye must always be on guard to insure a proper and healthy condition of the sinking funds.

Sinking Fund Adjustment.—There are several ways in which adjustments in sinking funds may be made. Should the annual inspection of the sinking fund show that there is a surplus, two remedies are presented. If the excess is not considerable, serial bonds issued by the city which have been bought up by sinking-fund installments may be amortized. This is perfectly sound procedure. In cases where the surplus of sinking funds over requirements is large, a recalculation is advisable in order to restore the funds to a proper balance and to distribute the benefit evenly over the present and future years. When recalculation is made, the estimated rate of earning should be based both on past experience and on the general outlook of the money market for a number of years to follow. There need be a weighing and balancing of money rates.

Should a slight deficiency exist, and all indications are that the sinking fund will earn at least as much if not more than was forecasted in the computation of the present annuity, then this deficiency may be ignored. If, however, the deficiency is considerable, due to misappropriations, inaccurate calculations, or an unexpected decrease in the return on investments, a recalculation of future requirements is imperative. A balance might also be secured by immediately restoring the deficient amount by placing the item in the current budget. When the deficiency is exceptionally large, refunding may be the best solution.

The examination of sinking funds is best explained perhaps by tracing the examination of a practical example which embodies all possible complications. That has been the attempt here. The procedure is traced step by step, with a full explanation of the correct solution for each of these complications.

The Example.—For the analysis here, assume a bond issue of $100,000 for a new city hall, dated June 1, 1920, for a term of ten years. The envestment of the sinking fund yields an income of 3½%. (The experience of each city must determine the average amount of earnings from all sinking funds.) There is $40,690.50 in the sinking fund on June 1, 1926. Assume the examination to be made on this latter date. The fiscal year begins January 1.

Objects of Examination.—1. To ascertain the amount of "annuity" which should have been set aside each year till maturity.

2. The sufficiency or insufficiency of the sinking fund on the date of examination. (June 1, 1926.)

3. The difference between the amount of the bond issue ($100,000 in this example) and the amount to which the present sinking funds will accumulate if invested to yield 3½%.

4. The future sinking-fund requirement (annuity to be placed therein) from the date of examination to the maturity date.

General Considerations.—In fulfilling these objects it will be determined if the provisions for meeting the bond obligation at maturity are based upon correct actuarial requirements. If the annunity has been incorrect, or if the return on sinking-fund investment wrongly forecasted (this being the only variable), or if the actuarial annunity has not always been placed in the fund, then there will be a greater or lesser amount in the sinking fund at maturity than the bonds outstanding. In this case a new annuity may have to be calculated upon an actuarial basis.

The date chosen for calculating the future sinking-fund installments should be at such time in the future that the municipality will be enabled to make adjustments in the budget for the recommendations. Care must be taken to compare as of the same day the amounts that should be in the sinking fund and the actual holdings.

Since annual annuities are paid into the sinking fund at the end of the bond year, it is easier to make an individual analysis by calculating sinking-fund holdings as of the anniversary date of each particular issue. If the summarized condition of all sinking funds of a certain date is desired, then the amount which should be in the sinking fund for each issue should be calculated in a fractional part of the year to include the interest accrual to that date. However, as the exact return on sinking-fund investments is a variable, the omission of this fractional interest accrual will not cause much inaccuracy. As sinking funds should be inspected each year, such fractions may be ignored.

Steps of Procedure.—In analyzing sinking funds according to the following guide, the several steps should be arranged in columnal form giving the title of each step as the heading of the respective columns. In fact, the procedure would be somewhat clarified if the particulars and calculations used in the example were set up in this columnar form.

Titles and Explanation of Steps.—

1. Purpose (or Name) of Issue—(City Hall Bonds).
2. Date of Issue—(June 1, 1920).
3. Terms of Bond—(10 years).
4. Date of Maturity—(June 1, 1930).
5. Amount of Bond—($100,000).
6. Yield on Sinking Fund Investment—(3½%).

   This is the return on the investment of the sinking fund.

7. Number of Possible Installments—(10).

   This is the number of annual installments that can be paid into the sinking fund at the end of the bond year. Where peculiar state, tax, and budget laws exist it might be that an installment on the first anniversary cannot be provided. Therefore, there will be one less installment than the term of the bond.

8. Number of Elapsed Installments—(6).

   This is the number of times to the date of examination in which installment should have been made.

9. Factor to Accumulate to $1.00 at Maturity—($0.0852414).

   This is the amount which set aside annually at compound interest at the end of each year for the number of year corresponding to the "Number of Possible Installments" (Item 7) would produce $1.00 at the end of the bond period. This is ascertained from a sinking fund table. Any standard annuity table will suffice. "Highway Bonds," Bulletin 136, of the United States Department of Agriculture, contains tables which are admirable for these calculations. The particular table for this computation is that which shows "the annual sinking fund which will accumulate to 1 at the end of 'n' years." This is Tab'e 23 in the bulletin just mentioned. Under the columnar headings, pick out the 3½% interest column, run down the column until the figure is reached which is opposite 10 years, the "Number of Possible Annual Installments."

10. Annuity to Produce Amount Due at Maturity—($8,524.14).

    This is obtained by multiplying the preceding figure by the amount of the bond in question (Item 9 by Item 5). If this amount had been set aside each year and the interest on it had remained constant, the holdings would exactly equal the amount outstanding at the maturity of the bond.

11. Accumulation of an Annuity of $1.00 at the End of Elapsed Installments—($6.5501522).

    This is the amount accumulated by the investment of $1.00 at compound interest. This is ascertained from the table which shows "the accumulation of an annuity of 1 per annum at the end of 'n' years"—Table 22 in "Highway Bonds." Under the columnar headings pick out the 3½% interest column, run down the column until the figure is reached which is opposite 6 years, the "Number of Elapsed Installments."

12. Amount Required in Sinking Fund—($55,833.12).

    This is obtained by multiplying the last two figures (Item 10 by Item 11). This is the amount which should be in the sinking fund if the proper annual annuity had been set aside and invested at 3½%. An examination may be made for some other date than the bond anniversary date as assumed. If the bond year is more than half over, the interest accrued for the elapsed half year can be figured into the amount required in the sinking fund. In such case the number of months elapsed between the last anniversary date of the bond issue and the date of examination should be derived. If this is over six months, one-half of the regular interest rate will have accrued to the amount in Column 12. This is then added on to determine the exact amount in sinking fund. Appropriate columns, numbered 12a and 12b, should be included in the chart in case this is done.

13. Actual Amount in Sinking Fund—($40,690.50).

    This is the actual amount which the audit shows to be in the sinking fund at the date of examination.
    This brings up a question. Sometimes there occurs one lump sinking fund account for different bonds or bonds sold at different occasions for the same or similar purposes. If an examination is being made of a number of such bonds, it will be necessary to prorate the total sinking-fund holdings to each particular issue. This is accomplished by using a ratio of apportionment for each issue. This ratio is obtained by dividing the "Amount Required in Sinking Fund" for each issue by the total amount of all issues required in sinking fund, that is, each figure in Column 12 by the total amount of Column 12. There will be as many ratios as there are different issues. When the total "Actual Amount in the Sinking Fund" (Item 13) is multiplied by this ratio, a product is obtained which is the amount due to the sinking fund of each issue. This issue is called the "Amount of Apportionment."
    If this step must be made, two additional columns must be set up—13a entitled "Rate of Apportionment" and 13b "Amount of Apportionment." Therefore, 13b or the "Amount of Apportionment" is the "Actual Amount in the Sinking Fund" for each issue and, when this step is necessary, this figure will be used for future calculations.

14. Deficiency or Excess of Sinking-Fund Holdings—($15,142.62).

    This is the difference between the last two columns. (Item 13 less Item 12 or Item 12 less Item 13, according to which is the larger.) A main column entitled "Difference" might be set up with "Deficiency" and "Excess" as two divisions; at any rate, the amount should be clearly marked.

15. Number of Unelapsed Installments—(4).

    This is the number of possible annuity installments which can be made before maturity. It equals the difference between the "Number of Possible Installments" (Item 7) and the "Elapsed Installments" (Item 8).

16. The Accumulation of $1.00 at Maturity—($1.1475230).

    This is the amount $1.00 invested at the time of examination of the sinking fund will produce at the end of the bond period at compound interest. The compound interest table showing "the accumulation of 1 at the end of 'n' years" (Table 21 in "Highway Bonds") will give the amount in the 3½% interest column and opposite 4 years, the "Number of Unelapsed Installments."

17. Amount in Sinking Fund at Maturity—($46,694.35).

    This is the amount which would be produced at the end of the bond period by investing the present sinking fund holdings at compound interest. It is obtained by multiplying the "Accumulation of $1.00 at Maturity" (Item 16) by the "Actual Amount in Sinking Fund" (Item 13).
    In our example the examination of the sinking fund occurs on June 1, 1926, just after the installment for the previous bond year has been made. The next anniversary of the bond year (June 1, 1927) will be in the coming fiscal year beginning January 1, 1927. The budget for this coming year has not been made up. Hence, the annuity which is now being installed in the sinking fund (Item 10) can be changed. If the budget now in force provides for an installment to be made after the date of examination, the amount of this annuity cannot be changed till a new budget is made up. This situation would exist in our example if the examination were made between January and May 31st. Since this is not the case in this example, the next step in the analysis is that indicated by Item 22. However, should a change in the annuity for the next installment be impossible, steps indicated by Items 18, 19, 20, and 21 must be included.

18. Number of Possible Installments of Revised Annuity—( ).

    This will be one less than the "Number of Unelapsed Installments" (Item 15).

19. Accumulation of an Annuity of $1.00 During Number of Possible Installments of Revised Annuity—( ).

    This factor is obtained in a similar manner as Item 11, the number of years shown in Item 18 being used.

20. Amount of This Additional Annuity Installment at Maturity—( ).

    This is found by multiplying the factor in Item 19 by Item 10, this latter number being the amount of the installment. The result is the accumulation of this annuity installment at maturity. It must be added to the amount in Item 17 This is Item 20 plus Item 17. and placed in Column 21.

21. Revised Amount in Sinking Fund at Maturity—( ).

22. Shortage or Excess at Maturity—($53,305.65).

    This is the difference between the "Amount on Hand in Sinking Fund at Maturity" (Item 17) or the "Revised Amount" (Item 21) and the "Amount of Bond" (Item 5).
    If this amount is less than the bond issue, future annual installments must be made to the sinking fund in order to provide adequate redemption for the bond issue. Should this amount be more than the bond issue, as has actually happened, a position of the present sinking fund holdings may be diverted elsewhere, or the excess at the time of maturity may be utilized for other purposes. In the latter instance, the sinking fund can be left alone with no more installments made.
    The procedure for diverting enough of the present sinking fund holdings to

have the amount in sinking fund at maturity equal to the amount of bonds will be shown in the steps indicated by Items 23a, 24a, and 25a. If this is the case, the steps indicated by Items 23, 24, and 25 should be omitted, as these outline the procedure where a shortage is found.

23. **Factor to Accumulate to $1.00 at Maturity—($0.2372511).**

This is the amount which set aside annually during the "Number of Unelapsed Installments" (Item 15) will produce $1.00 by maturity. This is ascertained from the same table used and explained in Item 9. In case the steps indicated by Items 18, 19, 20, and 21 are necessary, it is the amount set aside annually during the "Number of Possible Installments for Revised Annuity" (Item 18).

24. **Annuity Necessary to Produce Amount Due at Maturity—($12,646.76).**

This is obtained by multiplying the "Factor to Accumulate $1.00 at Maturity" (Item 23) by the "Shortage at Maturity" (Item 22). This is the amount which when invested at interest (3½% for example) will produce an amount equal to the difference between the amount of the bond maturing and the amount produced by the present sinking fund holdings, or Item 22.

25. **Increase or Decrease in Annuity to Be Installed Annually in Sinking Fund—(plus $4,122.62).**

This equals the difference between the amount it has been the practice to set aside (Item 10) and the amount necessary to set aside (Item 24). Two columns may be made of this; at least it should be clearly marked whether it is an increase or decrease.

The following steps are necessary only should there be an "Excess in Sinking Fund at Maturity" as explained in Item 22, and it is desired to divert the excess at the present time. To find the amount of this diversion, it is necessary to find the required amount that should be in the sinking fund at the present time which at compound interest will equal the "Amount of the Bond at Maturity." This will be subtracted from the "Actual Amount in Sinking Fund," the difference being the amount divertable from existing sinking-fund holdings.

23-a. **The Accumulation of $1.00 at Maturity—( ).**

This factor is derived from the same table and in the same manner as was explained in Item 16. It is found in the appropriate interest column and opposite the number of years corresponding to "Number of Unelapsed Installments" (Item 15).

24-a. **Present Amount Necessary in Sinking Fund—( ).**

This total amount of the bond should be divided by the above factor in 23a and the quotient entered in this column. It is the amount in the sinking fund which will accumulate at compound interest to a sum equal to the amount of the bond.

25-a. **Amount Divertible from Existing Sinking-Fund Holdings—( ).**

This is the difference between the "Actual Amount in Sinking Fund" (Item 13) and the "Present Amount Necessary in Sinking Fund" (Item (24a).

In case no sinking-fund provisions were ever made for a bond issue, an annuity must be placed annually in the sinking fund, beginning with the first possible installment, which is sufficient to equal the amount of the bond at maturity.

All of the objects of the examination have been fiulfilled. If every bond issue is analyzed in this manner, the sinking-fund requirements and all necessary information will be obtained. The above analysis shows that the examination and calculation of sinking-fund requirements are comparatively simple matters and do not require the use of an involved and mysterious technique. By means of a simple procedure, such as this article attempts to set forth, any public official should be willing to accept full responsibility for sinking-fund administration.

No attempt is made to suggest the charts, ledgers, and calendars necessary for sinking fund administration. For this information, and for a very practical treatment of the subject as a whole, Chapter XIV on Debt Administration in A. E. Bucks's "Municipal Finance" is recommended.

Sanitary Service in St. Paul

Costs Reported for Year 1926 by Commissioner of Public Works

The City of St. Paul has 400.0 miles of streets graded only; 26 miles of macadam roads, 203.9 miles of paved streets and 11.8 miles on paved alleys.

The paved areas—streets, bridges and alleys—amount to 4,710,000 square yards. Of this, 58 miles or an area of 1,365,000 squard yards are cleaned by hand sweeping under the patrol system. The districts for each sweeper vary from 3,200 square yards in the business district to 17,000 square yards in the residential sections.

Snow removal, including sanding of walks and steps, amounted to $20,007.34; of this the Street Railway Company paid as their portion $2,175.78.

In addition to the sweeping service, all paved streets are cleaned with water periodically. This is done with Studebaker Flushers and auto flushers. 148 miles of streets were flushed. In the retail district the streets are flushed every night. In the outlying districts flushing is done as required.

Forty-one miles of streets were water sprinkled for the entire season; 231 miles were treated with oil; this includes streets which were water treated the early part of the season and then oiled.

The rate for water sprinkling, four trips per day, was 12.88 cents per frontage foot, or $5.15 for a 40-foot lot, for the season. The rate for oiling, two oilings per season, an average width of 24 feet, was 5.28 cents per foot, or $2.11 per 40-foot lot. The oil is distributed by Kinney Auto Oilers, using 779,938 gallons of road oil.

Where dust was laid by flushing the following rates were used:

Night flushing, daily	$0.13	per frontage foot
Flushing every five days	.02½	per frontage foot
Flushing twice a week	.04	per frontage foot
Flushing once a week	.02	per frontage foot

Sixty thousand two hundred and fourteen lots or parcels of land were assessed for sprinkling and oiling. Some of the lots were assessed for both, making a total of 92,744 separate assessments.

During the year 67,825 lin. ft. of sewers have been flushed with fire hose. This required 6,245,000 gallons of water. The Water Department was reimbursed on a basis of 40 cents per hour (624.5 hours) for the time hydrants were open during the flushing. The charge of 40 cents per hour was based on an average of meter readings taken at various hydrants in this city.

Dead Animals Collected During Year of 1926

Horses	359
Cows	28
Calves	39
Colts	40
Pigs	22
Dogs	6,845
Cats	5,658
Chickens	73
Sheep	73
Rats	10
Goats	3
Mules	2
Total animals	13,098

Delivered to Union Rendering Plant, South St. Paul, Minn.

Garbage Collected by Trailer System—1926

Months	Number of trailer teams	No. loads collected per month	Tonnage collected per month	Average tonnage per day	Cost per ton
January	12	615	578	22.23	$7.41
February	12	546	464	20.17	8.17
March	12	633	558	20.66	7.93
April	11	578	609	23.42	6.77
May	11	533	638	25.50	5.81
June	10	518	785	30.21	4.49
July	10	512	870	33.46	3.97
August	10	517	1,137	43.73	3.04
September	10	507	1,319	52.76	2.55
October	10	512	895	34.42	3.84
November	10	476	638	26.58	4.99
December	10	462	483	20.12	6.46

Total number of loads	6,409
Total number of tons collected	8,974
Average tonnage per day	29.5
Average cost per ton	$4.89
Total cost for collection	$43,905.20

The Prevention of River Pollution

A Discussion of the British Problem, That May Aid Similar Work in the United States

By FRANK A. B. PRESTON, F.I.S.E., M.R.S.I., Etc.

Burgh Surveyor, Milngavie, Scotland; Lecturer on Municipal Engineering, Royal Technical College

In a paper read before the British Royal Technical College, Civil Engineering, and reported in "The Surveyor," London, Mr. Preston called attention to the importance and the baffling nature of the stream pollution problem. After calling attention to the unsatisfactory nature of the Rivers Pollution Act, of 1876, that is supposed to control the matter in Great Britain, he proceeded to point out the weaknesses in that law and in other ordinances in existence in his county. He then stated that a modern law on the subject had been proposed to Parliament.

In discussing the matter he favored the adoption of a "standard sewage effluent," and said that it would have to be related in some way to the dry weather flow of a stream, as representing the worst conditions. The Royal Commission on Sewage Disposal, he said, recommended as a general standard that in case of dilution eight times or more, matter in suspension should not exceed three parts per 100,000. Proper management, he said, must be exercised to see that the sewage treatment plant continues to operate efficiently. A high order of technical knowledge is required with some modern types of installations.

Disposal of Effluents.—In discussing methods of disposing of polluting trade effluents, Mr. Preston claimed that many involved factors require careful consideration, and recourse must be had to scientific knowledge quite outside the field of civil engineering. Industrial interests, water supply, water power, fisheries, air purity, and other points must be considered in setting a standard of water purity. He warned against setting a standard at the point where fish life can be maintained, since different species of fish show different degrees of resistance, and since fish life may be destroyed by the destruction of their natural food, whether vegetable or insect.

Fish Food.—Biological investigation is required on the subject of what fish feed on in a stream in question and what trade wastes are harmful to such food. It is a proven fact that fish life depends upon small water animals and plants, which are fed upon by such organisms as snails, insect larvae, etc., which in turn furnish food for some species of fish. The destruction of these basic organisms will therefore prove detrimental to the fish life in the stream.

River Pollution and Fish Life.—Mr. Preston dwelt at length upon the effect of various types of pollution on several species of fish native to British waters. He spoke of post mortem examination of fish to betray the state of stream pollution, and cited a case of trout killed by intermittent discharge of highly alkaline effluent from a bleach works, where the fish were obviously affected through the gills and through the alimentary canal. He then spoke of experiments made by Hein, Steinmann, and Surbech, published in 1908 and in 1920, to observe the effects of tar pollution. Tar, a pollutive material emanating from gas works, and from some types of roads, is shown to be a nerve poison which irritates the respiratory organs of fish, causing difficult breathing and even suffocation. Trout, he reported, generally are killed by concentrations of 1 to 80,000 parts in eighteen to twenty hours, while other varieties of fish are more resistant. Water that has taken up tar poisons retains its toxicity for a long time. Crustacea which are gill-breathing have from three to six times the resistance of trout, while larvae such as that of the mosquitoe do not appear to be influenced. Of the tar substances, napthalene is the most deadly.

Similar investigations into the biological factors involved in destruction of river fisheries by pollution due to lead mining have been made by Miss Kathleen E. Carpenter, M. Sc., of the Zoological Department of the University College of Wales. From a summarized report on her work, it appears that the destruction of fish is due, not to the galena-grit found in the river beds, but rather to the presence of metallic salts dissolved in the water.

This raises an important source of river pollution—namely, from spoil heaps. Pollution has been observed from chemically polluted bings of china clay at paper mills, and where necessary the surface water from such dumps should not be permitted to flow directly and untreated into a stream.

Detection of Pollution.—Of the bacteriological examination of river water for the detection of pollution he suggested its value in relation to the detection of sewage pollution where B. coli may be found.

The chemical analysis of polluting trade effluents is of great importance. The samples to be tested should be taken under proper conditions, and it is frequently advisable where legal action is pending, before witnesses representative of both parties. If the results are laid down on a graph, valuable information with regard to the days and hours at which maximum pollution usually occurs may be obtained. With constant attention visual signs of certain types of such pollution can be detected. In this connection there is need for the standardization of the methods of chemical analysis so that scientific comparisons may be available.

Standards for Trade Effluents.—There remains the question of setting up statutory standards for trade effluents. This is a debatable question. More or less local arrangements as to the quality, quantity and temperature of trade effluents being discharged into streams or public sewers have been adopted from time to time.

Local authorities and their technical advisers are well advised to study the possible effects on their sewage disposal plant of trade effluents before accepting same. Where works are unable to digest such effluents a local authority may find itself, in consequence of acceptance, responsible for discharging a polluting effluent from their works. Investigations as to the probable action of waste waters on sewage should be examined, both from a chemical and bacteriological viewpoint, and it must not be forgotten that results obtained under laboratory conditions do not necessarily closely approximate conditions in practice. The acceptance of such effluent into a small disposal works is of exceptional importance, as the volume of works effluent in such a case might at times exceed the entire volume of domestic sewage. A similar hardship does not exist in connection with the acceptance of similar effluent at large disposal works where facilities for proper disposal exist, and where emergencies can be met by a proper qualified staff possessing the requisite technical knowledge.

Preliminary Treatment.—In connection with either class of disposal works there appears to be adequate reasons for advocating the desirability of insisting on preliminary treatment by manufacturers of trade effluents before discharge into sewers. It is remarkable, in this connection, how such a suggestion is resisted by trade representatives, even where such treatment can be adopted by them to their economic advantage.

Take the case of paper mills discharging an alkaline waste water—a highly polluting effluent. In esparto grass mills it is found profitable to evaporate the liquid from "boilings," first washings, and "coolings," and recover the alkali as carbonate of soda. In this way 75 per cent of the soda can be profitably recovered for re-use. Again, refuse from such mills contains in suspension considerable quantities of

fibre. This fibre can be, in a mechanical way, a considerable source of nuisance by clogging the surface of filter beds.

Some time ago a fibre-collecting plant was introduced at one mill. The esparto grass was passed through a mechanical chain beater before treatment, and the loose dust and fibre sucked off by means of enclosed electric fans and collected in large cylindrical collecting bags. A market was found for the waste matter, now recognized as a by-product, from which wax is recovered.

Such examples illustrate the point that in many instances manufacturers can, to their own advantage, reduce the noxious nature of their trade discharges.

A Progressive Problem.—From both an engineering and scientific standpoint the disposal and treatment of trade effluents is a progressive problem. New industries arise, such as have occurred by the establishment of creameries and beet-sugar factories, to which further reference will be made. So far as engineering considerations are concerned, the treatment of the waste liquids is dependent on their amenability to mechanical, chemical, or bacteriological treatment, and of the provision of the necessary plant for such purpose.

For paper mill effluents settling tanks are a necessity, and the supernatant water from same should be passed over filter beds. In some cases the addition of alumino-ferric will assist in clarifying the liquid while in the tanks. Neither the settling tanks nor the filter beds need be of any great depth, but must be of adequate area. Where levels do not permit of running of sludge into sludge pits the sediment requires to be dug out of the settling tanks. Filter beds consisting of hand-set stones 12-in. in depth covered with ashes to a depth of 12 in. have been adopted at some mills. Various types of settling tanks and filters are used for textile trade fluids and dye refuse. Patent trade effluent plant for dye refuse is available.

Liquid Wastes From Creameries.—The disposal of liquid waste from creameries and milk-handling plants presents problems that tend to increase, and with the tightening up of legislation in relation to the handling and distribution of milk will in all probability greatly extend in this country.

It has been found that dilution is not too effective even where the outfall is into a large canal, particularly during the summer months. Land treatment is effective where the geological nature of the soil is suitable and an adequate area utilized, or where efficient dilution is also adopted.

In the case of one such plant dealing with about 1½ million gallons of milk per annum, the purification works for waste waters were erected in 1913. The waste waters are collected in an underground tank holding one day's supply. The refuse is pumped, along with sufficient lime to neutralize same, into an overhead tank of two days' capacity. The lime precipitate which settles on the tank bottom is discharged into tank carts and disposed of on the land. The effluent passes into two septic tanks, together of one day's capacity, and is subsequently discharged on to a clinker filter bed roofed over so that frosts do not interfere with its action. Distribution over the filter bed is effected partly by means of a traveling distributor and partly by means of very porous concrete slabs placed on the surface of the filter. These concrete slabs are very effective distributors retaining the solid matter which would clog up the filter. The concrete slabs can be removed when necessary and cleansed by a hose pipe.

The volume of waste water was estimated at 2,500 gallons per day, but is now more than double that amount. The filter is 20 ft. long, 14 ft. wide, and about 6 ft. deep. On the assumption of 5,000 gallons of waste water per day the filter treatment is equivalent to 84 gallons per cu. yd. per day. The filtrate is passed through a small humus tank and strained through a suitable sand filter. Analysis has shown the final effluent to be non-putrefactive. The cost of the purification works in 1913 was approximately $2,500.

Beet Sugar Factory Wastes.—Consequent on the erection of beet factories in this country a new type of polluting trade effluent deserves special mention. The original extraction of sugar from white beet *(Beta Vulgaris)* was made by the Prussian chemist Marggraf about 180 years ago. In the interval by scientific cultivation the sugar yield has been doubled and in some cases almost trebled. Fortunately, from the point of view of the prevention of river pollution, the period of manufacture extending to about 100 days, known as the "campaign" period, is from October to March. Had the manufacturing process been in progress during the summer period associated with higher temperatures and dry weather river conditions the evidence available seems to indicate that acute pollution would result.

The large quantities of water required for the industry make a river bank situation almost imperative. In a factory handling 1,000 tons of beet per day about four million gallons of water are required for transporting and washing roots, and a further 600,000 gal. for the process of extraction. The water used for transporting and washing is charged with inorganic matter consisting of earth, sand and stones, and organic matter such as beet tails, etc. The former, if discharged directly into a river, would form mud banks, and the latter through decomposition would pollute its waters. The extraction water, containing as it does organic matter in solution, is also liable to cause pollution through decomposition. Damage to fish and other stream life appears to be due to both direct poisoning and the development of masses of fungus. So far as the direct poisoning of fish is concerned the water from pulp presses appears comparatively harmless unless by poisons set free from subsequent putrefaction. Physiological tests on fish placed in these effluents have been carried out.

In a report dated May, 1926, Messrs. Roberts and Todd state that "From the point of injury to fisheries the soluble and decomposable insoluble contents of the effluent are the most obnoxious, and it is therefore interesting to note that the toxicity of the effluents tested appears to vary inversely as the cubic contents of the settling pits; in other words, it is the decomposition products which are toxic and not the pulp press water as delivered from the presses. Whether, however, the effect on the river would be greater or less if the pulp press water were delivered direct is unknown, and is a matter for observation and research."

Methods of Treatment.—Owing to the enormous volume of the waste water its effective treatment is difficult, and while investigations have been made into suitable methods of treatment a satisfactory method has not yet been evolved. The Dutch expert, Kessener, suggests:

(1) That the beet washing and transport water should be screened to remove root tips, etc., and thereafter passed through a series of sedimentation tanks for the extraction of earthy matter before being passed into the river. Too long retention in such tanks renders the effluent liable to putrefaction and cellulose fermentation.

(2) That the waste water from pulp presses which is liable to acid fermentation should be rendered alkaline by addition of lime and after passing through short deep settling tanks of Dortmund type, be passed through a percolating filter. In one case Kessener used 2 sq. meters (approx. 21.4 sq. ft.) of filter surface to 1 cube meter (approx. 264 U. S. gal.) of water per day.

The activated sludge process has been tried for dealing with pulp press water after the removal of its solid contents. It has been stated that a period of 15 hours' aeration is sufficient for purification.

In a report dated April, 1926, on three samples of effluent from beet sugar factories to the Ministry of Agriculture and Fisheries, the Government chemist showed on the basis of parts per 100,000 that the oxygen consumed in four hours at 80 deg. F. amounted to 6.23, 5.64 and 4.41, respectively. Two of the samples had a distinct odor of sulphuretted hydrogen.

Destructive Effluents.—There remains a class of trade effluent for which so far no adequate method of purification has been evolved. This group includes waste discharged from gas works, iron

and steel works, and coke oven plants. Effluents originating from such sources are of a particularly destructive nature to plant and fish life as well as to micro-organisms. These effluents are also destructive to the bacterial life on which sewage purification depends. To add to the difficulty of treatment the discharges are intermittent in character. Many local authorities have refused to accept for treatment the spent liquors from ammonium sulphate plants owing to their inability to devise adequate treatment for such effluents.

Spent gas liquor has an enormous capacity for absorbing oxygen, and a British Government report gives figures of 400 to 700 parts per 100,000 (measured by N/80 permanganate in four hours at 27 deg. C). The discharge of such effluent into a stream cannot be otherwise than highly objectionable.

Spent Gas Liquor.—In a memorandum issued by the Standing Committee on Rivers Pollution, the following methods for the purification of spent gas liquor are suggested:

(1) Mechanical methods.
(2) Chemical methods.
(3) Biological methods.

(1) Mechanical Methods.—The suspended solids, which are not so objectionable as the matter in solution, may be removed in settling tanks.

(2) Chemical Methods.—In chemical treatment the object is to precipitate or oxidize the liquor constituents and prepare same for bacterial treatment. Alum, alumino-ferric, iron and copper salts have been suggested for this purpose. Chemical treatment in which flue-gases are passed through the liquor appears to offer some solution if same can be satisfactorily used along with biological filters.

(3) Biological Methods.—When this treatment is adopted filter beds similar to those used at sewage disposal works are employed. Among the media suggested occur lignite, peat, etc., coke and animal charcoal. Blast-furnace slag has been recommended for the removal of sulphides and cyanides. In the alkali report for 1923 it is suggested that the character and size of the filtering medium is likely to influence the efficiency of the bacterial action. Certain experts claim to have isolated an organism said to be capable of oxidizing phenol. Biological reduction has been utilized at gasworks in Bradford and Manchester, England. The liquor diluted with nine volumes of water is passed through filters at the rate of 80 gallons per cu. yd. per day. Experiments made by Dr. McLean Wilson for the West Riding of Yorkshire Rivers Board "show that a spent gas liquor diluted until the oxygen absorbed in four hours in 400 parts per 100,000 is amenable to biological treatment." The filtering medium used was obtained from a biological sewage filter.

Some trial experiments have been made with this type of effluent on the activated sludge process. It would appear that filter treatment of dilute liquor gives very fair results, which may in time be improved by the isolation, incubation and acclimatization of suitable organisms.

Grit Chambers

Design of Structure at Decatur, Ill., Described in March Proceedings American Society of Civil Engineers

By R. S. RANKIN

The design of the grit chamber for Decatur, Ill., possesses certain peculiarities uncommon to other chambers. The chamber is located at the end of a 60-in. intercepting sewer about 14,000 ft. long. Beyond the grit chamber are the Venturi meter, Imhoff tanks, and the remainder of the treatment works. Between the grit chamber and the Venturi meter, area and sufficient head have been provided for future sewage treatment development. As a result of the provision there existed between the water levels in the grit chamber and in the Imhoff tanks, a difference in head, which varied for different quantities of sewage flow. The grit chamber design was based on the assumption that there would be a definite water level for any given flow through it with the water level at the outlet of the chamber lower by the amount which had been allowed for future devices. This difference in head is now controlled so as to produce a uniform velocity in the chamber.

Major Assumptions in Design.—In the design of the grit chamber, two major assumptions were made: (1) That the water level in the chamber would be the same as that in the incoming sewer;

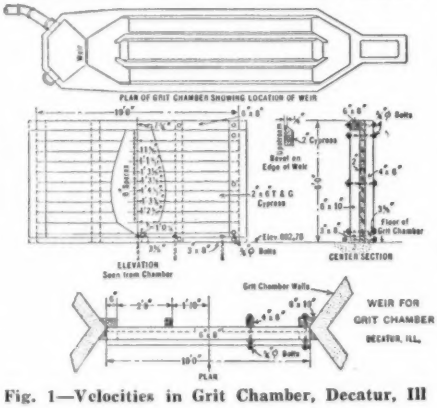


Fig. 1—Velocities in Grit Chamber, Decatur, Ill

that is, the water level would rise and fall the same as in the sewer; and (2) that not more than two of the three "flowing through" compartments in the chamber would ever be used at one time.

The quantity and the level of the flow in the incoming sewer, which is 60 in. in diameter, varies according to the usual curve of a sewer having a circular cross-section. It was decided that an optimum velocity of 1 ft. per sec. would be desirable in the grit chamber. The theoretical cross-section that would produce this required velocity was computed for various levels. It was slightly modified to straighten out the irregularities to a section which would be readily constructed.

With the water level at any elevation corresponding to that in the incoming sewer, the theoretical flow and

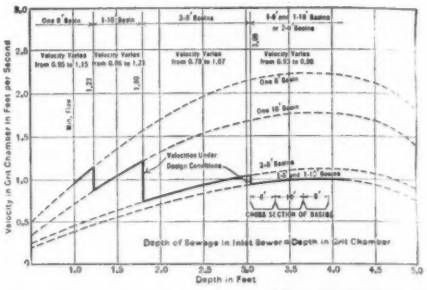


Fig. 2—Plan, Elevation and Section of Grit Chamber.

velocity in the grit chamber will be very close to 1 ft. per sec., as shown in Fig. 1.

Design of Weir.—In order to use up the head at the outlet and still maintain the correct level in the grit chamber, it was necessary to design a rather peculiar weir. This weir is of the submerged type designed on the basis that at any level there would be a definite head available for discharge. After several cut-and-try computations, a theoretical profile of the weir was determined and a section approaching this as nearly as practicable was adopted. The weir with this profile was constructed of wood and installed in the outlet as shown in Fig. 2, with the idea that modifications might have to be made. However, no modifications in the weir have become necessary, as current meter measurements in the grit chamber from time to time have shown that the velocities are very close to 1 ft. per sec.

The drainage of the grit chamber is accomplished by under-drains placed in a recess along the sides and near the bottom of each "flowing through" compartment, and consist of gravel-packed drainage pipes laid with open joints. The gravel is held in place by cast-iron gratings set flush with the side-wall of the chamber.

For removing the grit from the basin, each compartment has been provided with three outlets of 18-in. cast-iron pipe with a gate-valve control. The grit chamber is set high enough above the ground so that dump cars may run beneath on industrial tracks and the contents of any chamber may be discharged through these outlets directly into the cars.

The control of the flow is accomplished by means of wooden stop planks at either end and a swinging wooden gate at the inlet end. The operation of the grit chamber in general has worked out satisfactorily and conforms substantially with the design.

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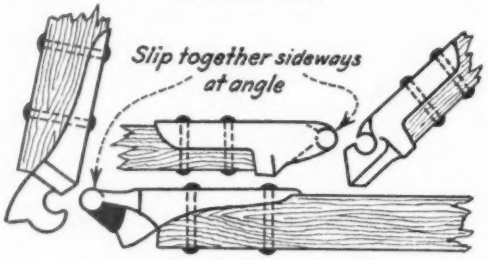

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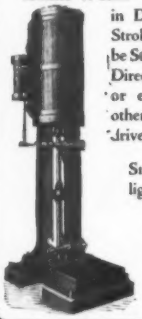

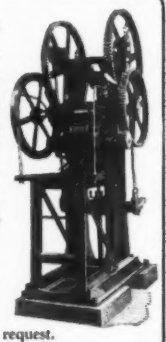

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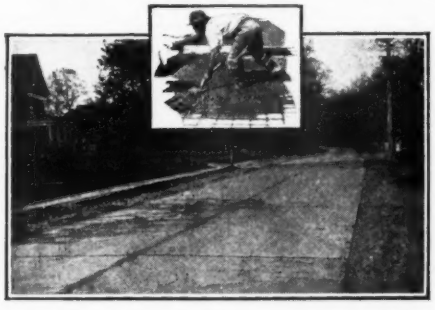

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